Homi Bhabha Curriculum for Primary Science

SMALL SCIENCE

Teacher's Book
Class IV

Jayashree Ramadas

Homi Bhabha Centre for Science Education
Tata Institute of Fundamental Research, V. N. Purav Marg, Mankhurd, Mumbai 400 088.

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author
Jayashree Ramadas

research assistance
Suchitra Varde

design and illustrations
Karen Haydock

printed at
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Amrut Nagar,Ghatkopar (West)
Mumbai - 400 086

general co-ordinator
Arvind Kumar

primary science co-ordinator
Jayashree Ramadas

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GENERAL PREFACE

Not a day passes in our country when somebody somewhere has not criticized our system of education, particularly our school education. A great many ills and inadequacies of the system probably flow from extraneous causes and need socio-political initiatives that go beyond mere reforms in school curriculum. But some problems do arise directly from the curriculum - text books, teaching and evaluation practices. There is then a need to keep these problems in view and continually try to devise new curricula to overcome them.

Efforts in curricular reforms and innovations are not new to our country. Nearly every decade or so, there have been initiatives at the Central and State levels to effect changes in curricula. Several independent school networks and voluntary groups have brought out their own textbooks and related materials. There is no doubt that significant progress has been made by the country in increasingly better conceptualization of the school curriculum at primary, middle and secondary levels. The paradigms of school curriculum in India have steadily evolved and become more relevant and modern. Unfortunately, the over-all deterioration of the system due to extraneous factors has tended to obscure these gains. Also, and most important for our purpose here, there is a large gap between the generally agreed objectives of the curriculum and their actual translation into textbooks and teaching practices.

Homi Bhabha Curriculum is basically an attempt to close this gap as much as possible. It is not conceived to be a revolutionary curriculum. The broad aims of the curriculum are much the same as those articulated in countless reports and articles of different education departments and agencies. The idea is not to produce a fanciful, 'museum-piece' curriculum that nobody would adopt, but to attempt to discover a sound and wholesome curriculum that is practical to implement in our school system. 'Practical' is, however, not to be regarded as a euphemism for the status quo. As the users will find out, the alternative textbooks of the Homi Bhabha Curriculum are full of radical unconventional ideas that we believe are both

urgent, necessary and, given enough efforts, feasible. But rather than describe here what we believe to be these innovative aspects, we leave the users, students and teachers, to find and experience them. In the simplest and most favourable situations, devising a curriculum and translating it into books, laboratories and teacher manuals is a daunting task. In the complex parameters and constraints that govern our country's educational system, the task is formidable. Only time will tell if and to what extent the Homi Bhabha Curriculum is an effort in the right direction.

Arvind Kumar

PREFACE TO SMALL SCIENCE: CLASS III

The series of students' and teachers' books for the Homi Bhabha Curriculum are the out come of more than two decades of research and field experience at the Homi Bhabha Centre for Science Education (HBCSE). During these years, several projects have been undertaken to study problems related to pedagogy, students' conceptions, communication in the classroom, text and picture comprehension and cross-cultural issues in science learning. All the members of HBCSE, past and present, have in some way contributed to this curriculum.

Primary school students, particularly in rural areas, have rich, interactive experiences of the natural world. But lacking systematisation and clear expression, their observations and skills do not contribute to school learning. Urban students from literate homes, on the other hand, are often encouraged to ignore their natural surroundings, and to concentrate on bookish learning. As a result, most students miss out on the combination of systematic observation, analysis and articulation, which is essential for science learning.

The aim of the Homi Bhabha primary science curriculum is to engage students and teachers together in a joyful and meaningful learning experience. The curriculum is built out of simple, thematically organised, activities and exercises. The TextBook, WorkBook and Teacher's Book for each Class are meant to promote active learning in every sense. To use these books, students must get out of the mind-set of copying the correct answers from the blackboard or from other students. Small Science should not be just read, it should be done.

Any good curriculum should be dynamic, ready to face criticism and to change according to the needs of students and teachers. Please do send us your ideas and suggestions for improvement.

Jayashree Ramadas
jram@hbcse.tifr.res.in

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Jayashree Ramadas

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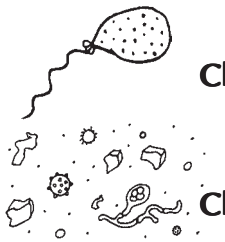

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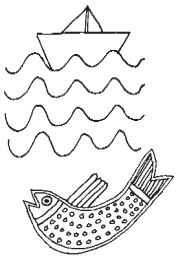

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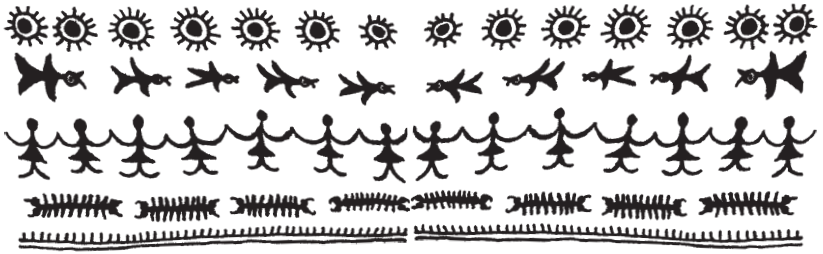


Introduction

EXPERIENCES OF USING SMALL SCIENCE CLASS III

Teachers, parents and students responded enthusiastically to *Small Science Class 3.* To teachers falls the difficult task of translating fine pedagogic theory into gritty practice, and their endorsement ("... these are the kind of books we were looking for without knowing it ...", "... for the first time I have come across activities which make sense and lead to real learning ...") has been especially gratifying.

There have been problems too, some due to the activity-oriented approach, others resulting from the unaccustomed emphasis on understanding rather than memorisation. We have tried to address these problems in the Class 4 WorkBook and Teacher's Book.

Six schools have formally adopted the curriculum - three of them use the Marathi version: *Halke Phulke Vidnyan. Eklavya* distributes the Hindi version (*Halka Phulka Vigyan*) in Madhya Pradesh. Feedback from these pioneers has been invaluable and resulted in some changes in the format of the Class 4 books. These books will now be pilot-tested.

A WORD ABOUT THE FORMAT

There are three books for each class: the TextBook, WorkBook and Teacher's Book. Each Chapter in the TextBook has two major sections, the Activities and the Exercises. The WorkBook provides a format for recording the results of activities and for responding to the exercise questions. It is to be used by the teacher for continuous evaluation of the student's work. Notebooks are not needed. The "Teacher's Book" includes the contents of the TextBook, along with practical help and advice on classroom teaching.

The Teacher's Book is written in the first person. It summarises our collective teaching experiences in different schools, with children from several different backgrounds. Your own experiences too can add to the books. Please do write and tell us how you like the books, and whether you find the ideas in them workable.

WHAT THE CURRICULUM IS ABOUT

Curiosity and learning

Children are by nature curious and observant. They learn about the world by watching, asking questions, and trying to make sense of what they experience. Science teaching should aim to encourage these natural tendencies. Hence this set of students' books, which have more questions than answers. These questions are an opportunity to involve the class in observations and discussions.

Traditional schooling trains students to *answer* questions - to come up with one correct response which satisfies the teacher and examiner. As a result however, students do not learn to look beyond the expected response, to frame their own questions, or to judge when a question has been answered satisfactorily.

In the Homi Bhabha Curriculum, we do not want students to simply parrot out a few correct answers. We want them to develop a lively curiosity about the world around themv-with a will to pursue answers through observation and inquiry. If they have this curiosity, they will learn, and become creative human beings too.

The textbooks interweave a story about two curious children, Mini and Apu, who learn many things by doing and asking questions. The text which follows this narrative encourages students to observe the world around them, to seek answers to questions, and to raise their own questions.

Science and basic skills

The aim of science teaching is to introduce concepts and ways of thinking that will help students interpret their experiences of the natural world. Science teaching should also provide new experiences, and enhance students' ability to enrich their own experiences.

The ability to gain and to interpret new experiences develops through the exercise of some basic skills:

1. Design and engineering,
2. Language
3. Quantitative thinking.

This science curriculum supports the development of these basic skills.

1. Design and Engineering

For too many years, this has been a weak point in Indian education. Students must start to use skills of drawing and constructing spontaneously in learning concepts. They should develop an attitude of, "let's do it and see!" For learning to take place, one needs the willingness to experiment, visual-spatial ability to design a situation, and manual dexterity to carry out one's plans. The curriculum offers many opportunities for students to construct with their hands, to put down their observations in drawing, and to develop simple concepts of design.

2. Language

Primary school children are actively developing their language ability. Language is a tool that will help them to conceptualise, to understand, and to express their thoughts. Language and expression is to be developed not just in language classes, but through the entire primary curriculum, including science and mathematics.

Throughout the curriculum, students apply their verbal and quantitative skills for more effective observation and inference. They also learn to communicate science knowledge.

3. Quantitative thinking

Quantitative thinking is to be developed not just in mathematics classes, but through the entire primary curriculum, particularly through science. Number skills will in turn help concept-formation in science.

Small Science Class 4 builds further on the elementary measurement skills introduced in Class 3. Since the whole idea of introducing mathematics into school science is new, the questions here might look unfamiliar. However both WorkBook and Teacher's Book suggest steps designed to take account of the difficulties. By working step-wise from Class 3 into Classes 4 and 5, and carefully following these procedures the new ideas could be made accessible to primary level students.

Facts or 'content'

On seeing the *Small Science* curriculum, some teachers express the apprehension that there is not enough information, or 'content' in it. Our response is that we want to develop a curriculum appropriate to the age and experience of primary school students. We choose not to load the TextBook with facts that often take up so much energy of the student and teacher that more meaningful learning is ignored. In any case such knowledge ends up being rote-learned and consequently is not retained in the memory for long.

Young children **are** hungry for new facts, new information, and we should not ignore this need. But, most of the facts that students need to know at the primary school level, exist in their surroundings, and often in the knowledge of older people. They can be found out through questioning and systematic observation. The teacher's job is to give students the tools to discover this knowledge, to whet their curiosity and develop in them a love for learning.

To guide the students thus, the teacher needs to be well prepared. Most everyday phenomena have complex explanations, and it is easy for a school child to come up with questions that would baffle a research scientist. To competently handle a wide-ranging classroom discussion, to keep the students interested, to respond intelligently to their questions, teachers do need to have their own store of organised information. In this Teacher's Book we try to give such information at appropriate points. Please note that this information is meant for the teacher, to be used in the classroom with discretion. It is not meant to be uncritically repeated, and certainly students should not be made to memorise it: that would defeat the purpose of the curriculum!

Concrete now, abstract later

Abstractions are central to science. As students grow older, they will be introduced to many new abstract concepts: often these create formidable difficulties in science learning in the later years. However, first-hand concrete experiences at a young age greatly strengthen the student's capacity to construct abstract formulations later on. On the other hand if abstractions are taught too early, they remain un-integrated with students' experiences.

This curricular approach is explicated in the Unit Overviews (see **What is new in this Unit**). Teachers will notice that the activities in *Small Science* do not merely serve to make the content interesting. They develop experimental skill and enable students to gain those concrete experiences on which later abstractions will be based. The activities are therefore an integral part of the curriculum. They cannot and must not be omitted. Subsequent text as well as evaluation exercises depend on completion of the activities.

Values in science

The books aim to impart certain values like, caring for living things, conserving resources, community living and working with the hands. Health and conservation issues are not separated as chapters but underlie the whole curriculum.

We also try to communicate that scientific enquiry into the external world does not exclude a role for feelings, emotions, as well as literary and aesthetic sensibilities. As much as possible, these values are not preached but conveyed implicitly.

Children's drawings

The TextBook includes a few pictures drawn by children. These pictures are meant to give children the feeling that their own childish type of drawing is of value - it is even good enough to be published in a book! Often children get discouraged and stop drawing, thinking that the only valid types of drawings are ones they could not possibly draw themselves - sadly most of us adults have lost the skill of thinking and communicating through drawing. Childish drawings do have real beauty, and they show self-expression that few professionals could.

Assessment

Young children love to learn facts about the world. But, children at this age also have short memories! It will be unrealistic to expect from them a total recall of facts. The assessment in this curriculum therefore does not emphasise factual knowledge. Rather, it focuses on, observation of environment, understanding, language and expression, design skills and quantitative thinking. These aspects of assessment are explained in the next section: 'Use of the WorkBook'.

There are to be no unit tests or final exams. The assessment is continuous, based on the student's writing in the WorkBook, as well as on their performance in the construction activities and oral exercises. Space is provided in the WorkBook for recording these grades. The supplementary exercises suggested in the Teacher's Book may be used as needed.

Opportunities for expressing one's own ideas and experiences are rare in our schools, which is one reason why language ability, even in late primary school, is often poor. While correct language should be introduced to students, credit should be given for accuracy of observations and originality of ideas, rather than for spelling or grammatical correctness. We expect this evaluation to provide a learning opportunity and not just to convey a verdict of pass/ fail.

HOW TO TEACH THE CURRICULUM

This curriculum proposes many new ideas; consequently we expect that many new situations will arise in the classroom. Some sample situations are discussed in this book, but it is not possible to do this exhaustively. Ideally, the curriculum should be implemented by a group of teachers in one school or in a group of schools, who meet frequently to discuss their ideas and problems.

The stories

The stories and poems are meant to arouse interest, and to raise students' curiosity about the topic. The stories often teasingly point ahead to ideas that the students would learn in later classes. Sometimes they might be a little difficult for all students to understand completely.

The language level of the poems might also be a little beyond the level of some students. The unfamiliar words in the stories and poems should be explained, but their scientific aspects need not be spelt out in detail. Evaluation questions also should not be based on them. These stories and poems are to be read "just for fun".

The activities

Most of the activities are to be done in school. In Small Science Class 3 no special equipment is asked for, but Class 4 we need some simple equipment like a thermometer, toy pump, hand lens, medicine dropper etc. The introductory section for each Unit lists the materials and other preparations required for that Unit.

Fairly extensive discussions are suggested prior to or after doing the activities. These discussions mentally prepare the students, clarify what is expected and show connections with their daily experiences. In some cases students' responses are quoted in some detail. These are meant give a flavour of how students can contribute their experiences to the classroom proceedings and thus put the content into a concrete personal context.

Often alternative (or wrong) interpretations are included. They illustrate that several possibilities for explanation do exist. It is not as important to give the correct answers, as to stimulate thinking. Each activity could lead to further questions, experiments, exploring the effects of variables, measuring, tabulating, graphing etc., but the scope of the activity is finally left to the teacher. Some activities might be developed as projects.

A common fear expressed by teachers is that activities may take up too much time; activities using water or mud, might lead to a messy and chaotic situation in the classroom. Sometimes, particularly in large urban classrooms, there might be a general problem of student indiscipline. In such cases prior planning of the lesson, and keeping students informed of the plan, helps tremendously. A sample lesson plan is given on pages 157-158 (Chapter 5, Activity 1).

Prior discussion with an experienced teacher helps too. It takes a certain amount of experience and ability to anticipate possible pitfalls and plan for them. Here are some suggestions (thanks to Dr. Karen Haydock):

1. Try out each activity for yourself beforehand.
2. Spend some time in the previous lesson explaining what the students are going to do and what material they might need to bring from home. If necessary allow an extra day to collect the materials and to remind any students who forgot.
3. Plan how the class will be organised - at their seats or working in groups; inside or outside the classroom.
4. Before starting on the activity make sure all the students understand what they will be doing, and why. Give the students time to ask questions.
5. Review any dangers or problems that might occur, and tell students what to do in case of an accident.
6. (For outdoor activities) Before going outside, explain what the students will do outside, where they should and should not go, and when they should return.
7. Get students to record the results of the activities in their WorkBooks. Exercises which need to be done during or immediately following the activities are usually indicated in the Teacher's Book. Part of the WorkBook may have to be completed at home.
8. Let students work independently as much as possible, while you concentrate your attention on the slower students or those who need encouragement.
9. Keep to certain routines in the classroom so that students know what kinds of things they are expected to do.
10. For example, set up a system whereby students clean up the place after the activity. Allow enough time for the clean up. Make sure there is a dust bin, cleaning cloth, broom, etc. available.
11. Give the students something to do in case they finish before the rest of the class - e.g. pick out a book to read, draw a picture, help clean up, write a poem about what they just did, go play outside, etc.

12. Summarise what the class did and what they found in the activity. If time is a problem this may be done in the lesson following the activity.
13. *Ask a question* should always be done with each activity. Even though each student will not come up with a question every time, this will provide enough opportunity through the year for all students to think of a few questions.

Field trips

It would be good to take the students outside the school twice in the year, once for teaching Unit 3 (living things in water) and once for Unit 4 (agriculture). If possible, observation of the night sky in Unit 1 is also recommended. For field trips it is best to take along one or more additional teacher, or some of the parents, or a helper. You should explain the purpose of the trip beforehand to the students as well as the helpers. A sample account of a field trip is given in Chapter 6 (pages 202-203).

New words

Know these words

Many new words are introduced in each chapter. Remember that their meanings should not be given in a formal way. Students should learn to use the words in sentences, not to reproduce the definitions. You might even explain the meanings in the local language, and then ask students to use these words in an English sentence.

The exercises

The exercises call for independent work by the students. They may need some explanation, or help with spelling or expression. But please do not ask students to copy standard answers from the board.

Observation-based exercises

1. Drawing tasks (*Name and Draw*)
These tasks are meant to encourage close observation (for example, drawings of the sky and clouds, of flowing water and of growing plants). Students' drawings should not be

copies of standard drawings, but should actually depict their observations. For this, the drawings should be done simultaneously with the observation and not much later. If the drawing teacher is willing to help, both observation and drawing could be done in the art class.

Children, and teachers too, are sometimes inhibited because they feel they "cannot draw". At this young age, it should be possible to overcome such fears, so that students learn to use drawings as a tool for learning and thinking. The drawings could be displayed in the classroom; touching up or "improving" these pictures by the teacher is **not** recommended.

2. Questions and discussions (*Interesting questions,Classroom discussion*)
The exercise questions are often based on the preceding activities or on extensions of these activities. To answer them students might have to recall their experiences in and outside the classroom and do some reasoning on their own. Since there is very little information given in the TextBook, questions based on recall of TextBook information are rare. Where needed, such questions can be easily framed by the teacher. Explanations accompanying the exercises are meant for teachers. Although several actual student responses are quoted here, students are not expected to give exactly the same responses. In fact many of the questions in these exercises do not have unique correct answers.

3. Similarities and differences (*What's the same, what's different, Find the odd one out*)
Exercises involving similarities and differences between a pair of objects or situations should be continually done in the course of actual observations. Finding differences and similarities calls for skills of critical observation and generalisation. Noticing similarities, which involves abstraction, is much more difficult than noticing differences. When choosing examples for this kind therefore, the two things to be compared should be obviously similar.

In finding the odd one out, if students come up with a valid response different from that indicated in the Teacher's Book, it should be accepted.

Language development exercises

1. Talk and write, Play with words

In *Small Science Class 3* students learnt to express simple ideas first orally and then in writing. They were encouraged to write from their own observations and experiences. This is emphasised because often, students are trained in school to write set essays on given topics. For example, they might have learnt to write an essay on a cow. When asked to write about an earthworm that is in front of them, they absurdly try to follow the same format as they used with the cow. With persistence however, even students with an initially low level of language development start to express their ideas.

Over the years, students' observations as well as expression should get more complex. The language development Exercises in Classes 4 and 5 have successively more critical thinking, argument and debate.

Though answering in full sentences is a useful habit, sometimes it may get tedious. The space in the WorkBook indicates where a one-word or one-phrase answer is sufficient. Exercises in *Play with words* are aimed at vocabulary development or just some fun with language.

2. Ask a question, Ask and find out

Ask a question should be done continuously through the year, particularly while doing the activities. Given the freedom to ask questions, students ask many, and many of these are very difficult to answer. The point is however, not to give a cut-and-dried answer, but to use the questions to encourage more and better observation.

The questions in *Ask and find out* relate to things that students can find out by asking their parents or other older people.

Some of the questions may be answerable by you or your colleagues or others. But even if you think that a question is too difficult, get students to think further by making related observations, for example, "Where else have you seen this? Are there situations where this does not happen?" Overall, students should get the idea that questions are

natural, and help in learning. All questions need not be answered immediately and satisfactorily at any level.

If you find the need for any information or clarifications, please write to the Homi Bhabha Centre for Science Education, marking the postcard or envelope "Homi Bhabha Curriculum - Primary Science".

Quantitative thinking

1. Figure it out and other exercises
In *Small Science Class 3*, students learnt the skills of seriating, estimating numbers and quantities, and carrying out elementary measurements using informal units. Measurements in Class 4 call for some standard units: centimetre, metre, gram, kilogram, millilitre and litre, which have been introduced earlier in the mathematics curriculum.

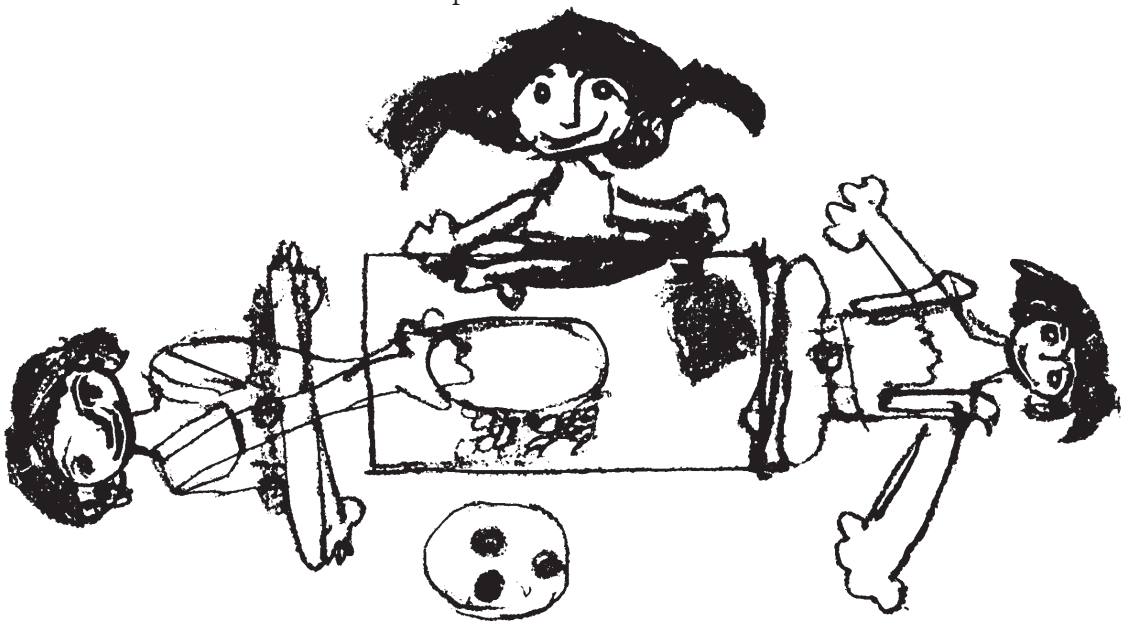
Quantitative thinking in Class 4 includes tables, charts, graphs and Venn diagrams. Graphical representations are introduced through picture graphs calling for shading of thermometers and water levels. Venn diagrams are introduced through concrete activities involving sorting of slips of paper.

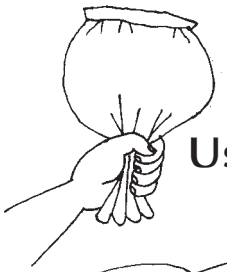
Did you know? Like the stories and poems, these are meant to arouse interest. No testing is to be done on this information.

Blackboard work Blackboards are an important and sometimes the only teaching aid in our schools. Sample blackboard layouts are suggested. They would give you ideas for better visual presentation of the content.

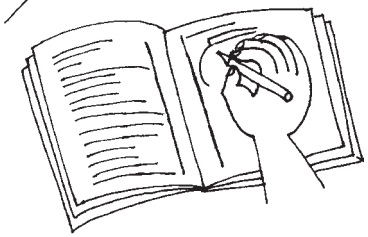
TIME ESTIMATE

The curriculum should work under minimal conditions; ideally it should fit into 200 hours of classroom time. Many schools in our country work under difficult conditions and even 200 hours of classroom time may not be possible. In terms of the concepts, skills and activities included, the book for Class 4 is more ambitious than the one for Class 3. (Estimated time for Class 3 is 164 class periods while for Class 4 it is 239 class periods.) Be prepared that it might not be possible to complete the whole curriculum satisfactorily during one academic year. Many of the activities and discussions could use more time. If an activity runs into more time than scheduled, it might be continued later as part of say a science exhibition or science club project. But if students appear to be benefiting from a certain learning experience, it would be worthwhile to take more time on it and cut down some of the other parts or ask students to do them at home.





Using the WorkBook



PURPOSE OF THE WORKBOOK

1. For the student

a. To record the results of the Activities
b. To solve the questions in the Exercises

2. For the teacher

a. To assess the student's progress
b. To provide feedback to the student and parents

FEEDBACK ON THE CLASS 3 WORKBOOK

Experiences of using the Class 3 WorkBook have resulted in some changes. We found that teachers and students were not always clear about the purpose of the Workbook. Some thought that the two books were identical except that the WorkBook provides space for responses. This is not entirely correct. The WorkBook provides a useful format for recording the results of activities. It suggests to the students where to focus, it raises supplementary questions to help reasoning and it forces them to stop and answer each question. In some cases the WorkBook is where the entire activity or exercise is spelt out and all the necessary illustrations, charts and graphs are included.

Page references given in the Class 4 TextBook as well as the WorkBook help students to correlate the two books. Also following feedback on the Class 3 books, page-wise grades are included in Class 4 and the Unit Assessment Sheets are simplified.

STUDENTS' WRITTEN WORK

A lot of observation and inference is expected of students. This is to be supported by classroom discussion. The written work follows from the observation, thinking and discussion. From the language point of view, there are three kinds of questions:

1. No written work

For some of the activities, little or no written work is expected. Design skills are mostly assessed independent of writing. The *Ask and find out, Show and tell* and *Act it out* exercises are purely oral. In the first two, information can be found out as home-work, and exchanged in a classroom discussion.

2. Single word responses

In many of the observation-based questions related to the Activities and the *Interesting questions*, only single-word responses are expected. In some places parts of the sentence are given.

3. Responses in complete sentences

In most of the language development exercises, that is, the *Talk and write*, and making sentences, students are to respond in complete sentences. In *What's the same, what's different*, sentence phrases are sufficient. In *Ask a question*, students have to frame a question and write it down. No written answers are expected.

STUDENTS' DRAWINGS

The *Name and draw* and other drawing exercises are used to assess observation as well as design skills. Drawings call for an ability to convert a real object or a situation into schematic form. To some extent, students learn here to distinguish the essential from the less essential aspects of a situation.

ASSESSMENT AND FEEDBACK

There are three parts to the assessment and feedback in the Class 4 WorkBook. The first part is the teacher's comments and corrections on the student's written and drawing work. The second part is the page-wise grading. The third part is the Summary Assessment Sheet for every Unit.

Teacher's comments and corrections

Space for comments and corrections is provided in the inner margin of the WorkBook. Whatever the quality of the student's work, the teacher's comments should provide encouragement as well as suggestions for improvement.

Assessment categories

The Assessment Sheet at the beginning of each Unit lists 11 categories that follow from the aims of the curriculum. The first six categories are to be assigned scores. For all the 11 categories there is space for the teacher's comments. As in Class 3, language has been given the maximum weightage. Considering the higher conceptual demand of the Class 4 curriculum, the category of 'Understanding' is added.

The categories are explained below:

1. Observation (O)

These include observations during classroom and outdoor activities and those contributed during discussions. Observation ability can be assessed in almost every activity and exercise in the curriculum. The assessment should include number, quality and variety. Students should notice details, and show them in both drawings and writings.

2. Understanding (U)

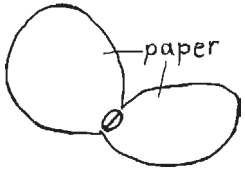
In a complete break from current practice, questions based entirely on memory or recall of facts, are not included in the TextBook. Rather, most questions aim to evaluate understanding. In one sense understanding can be thought of as a 'snapshot of knowledge', including facts, but more importantly, the connections between them.

A sample worksheet showing use of the comments and corrections column (for explanation of page-wise scores see page 19)

What are the differences between the seeds that blew easily and those that did not? The seed that blew easily were small and those which did not were bigger.
But what about the marigold seed and the mustard seed?

b. What could you stick to your seed to make it blow away with the wind?
cotton, bits of paper, small leaves.

A picture of my flying seed:



c. The birds I have watched:

flying Parrot

diving crow

landing sparrow

d. How far do they go?

Name of paper shape	Guess How far will it go?	Test How far did it go?
fighter aeroplane	3	3
unfolded paper	2	2
loosely crumpled paper	3	3
tightly crumpled paper	5	8
folded into rectangle	4	4
small aeroplane	4	2
envelope	3	3
rolled into slender shape	3	4

e. Did you make a spinning fish? No

OB
WB
DA

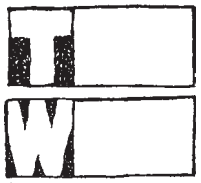
nice idea!

I'm surprised the small aeroplane didn't go farther, aren't you?

Please do it!

The second sense of Understanding is 'Analysis', which is more of a process, or 'knowledge-in-action'. Analysis is assessed through questions involving classification, compare and contrasts, inference, "what would happen if ..." etc.. The TextBook questions are demanding enough to enable us to assess not just the static picture of the students' knowledge but also their thought processes.

To achieve this objective, the teacher should definitely **not** give out the answers before students have had a chance to respond. If teachers give out the answers beforehand, the 'Understanding' tasks will get converted to memory-based tasks, and the whole point of this curricular approach will be lost.



3. Oral language (T) and **4. Written language (W)**

In most questions where the primary focus is language development, responses are expected in complete sentences. Vocabulary is tested in many of the observation questions involving single-word responses.

Assessment of oral language should consider the student's confidence and coherence. Clarity of expression is important in both oral and written work. In reporting observations, students should use descriptive adjectives and adverbs.

5. Design skills (D)

Assessment of design skills should include both the 'planning' and the 'doing' parts of manual activities. These activities include drawing, handling plants and animals as well as tools and equipment, seeing the connection between a material and its uses, constructing, measuring and plotting graphs and charts.

6. Quantitative skills (Q)

Every Unit has activities involving measuring, counting, tabulating, graphing, venn diagrams etc. Accuracy of responses is important, but so is a general tendency to think and to frame questions in quantitative terms. This should be encouraged whenever seen.

7. Enthusiasm in doing activities and **8. Patience and concentration**
Students should be enthusiastic in tackling new tasks, but also be capable of periods of quiet, concentrated work.

9. Independent thinking and 10. Co-operation with other students
We want to develop in students the ability to come up with original ideas, while at the same time being able to consider the ideas of other students and to work in a group.

11. Completion of home assignments
Some of the activities have to be done at home or information has to be found out from home. In Class 4 quite a few exercises may be given as home assignments.

Page-wise scores and averaging

- At the top of the inner margin of every page is the subset of assessment categories relevant to that page. Evaluate the student's work on that page and assign a grade from 0 to 4 for each listed category. Alternatively you might use the letter grades, E=0, D=1, C=2, B=3, A=4. Write this grade in the box for the category on that page.
- After completion of the Unit find the average score on each category over the whole Unit. Write this score in the Unit Assessment Sheet.
- It may not be possible to assign scores in every box on every page. For example if a student did not take part in one particular discussion listed on that page, no score on oral language (talking) might be possible for that page. In that case the average may be calculated over the available scores for that student.

Unit Assessment Sheet

Scores on the first six categories are to be calculated by taking averages over the whole Unit, as described above. All the 11 categories have space for the teacher's remarks. A sample filled Unit Assessment Sheet is shown on the next page.

The complete set of grades for the class would provide the teacher with a measure of his or her own effectiveness in teaching that Unit. The grades on all the categories in the four Units can be averaged to give a final grade for the year. In this system, each Unit is given equal weightage irrespective of the number of Chapters in it, or any differences in the qualities emphasised in each Unit.

Teachers might give grades of A, B, C, D, or E for each assessment box in the Unit, and then calculate the average for each category. To calculate the average, the number-equivalent of the grades can be used (A = 4, B = 3, C = 2, D = 1, E = 0).

For example, in Unit 2, suppose one student got the grades shown below (note that the teacher chose not to include all the activities and exercises given in the book). Then the teacher would calculate the total grades as follows:

O(Observation): (A+B+A+B+A+A+A+C+A+B+A+A+B)/13 = 46/13 = 3.5 = A
U(Understanding): (B+C+A+B+A+B+C+A+B+B)/10 = 31/10 = 3.1 = B
T(Talking): (A+B+A)/3 = 11/3 = 3.7 = A
W(Writing): (C+C+D+B+C+B+E+C+B+C)/10 = 20/10 = 2 = C
D(Designing): (A+B+A+A+A)/5 = 19/5 = 3.8 = A
Q(Quantitative): (A + D)/2 = 5/2 = 2.5 = B

This method allows the teacher some flexibility in fixing the final cut-offs for each grade (she can grade on a curve by adjusting the cut-offs so that only a few students get either very high or very low grades). If the teacher also has to give one total grade, she might average all of the grades for all the categories to get:

(46+31+11+20+19+5)/43 = 132/43 = 3.07 = B

In case the school requires numerical marks, this can be calculated as:

$$\frac{132}{43} \times \frac{100}{4} = 77\%$$

Sample
Assessment Sheet

Assessment Sheet: Unit 2

Category	Score	Comments
Observation	O A	I love seeing the wonderful, detailed pictures you draw!
Understanding	U B	You have shown very good understanding - especially of music (pitch, loudness)
Oral Language (Talking)	T A	Your comments and interesting questions always add to our class discussions
Written Language (Writing)	W C	Try to write the same way you speak. Read what you write to see if it sounds right.
Design Skills	D A	What a nice musical instrument you made!
Quantitative Skills	Q B	Good work on the music diagram

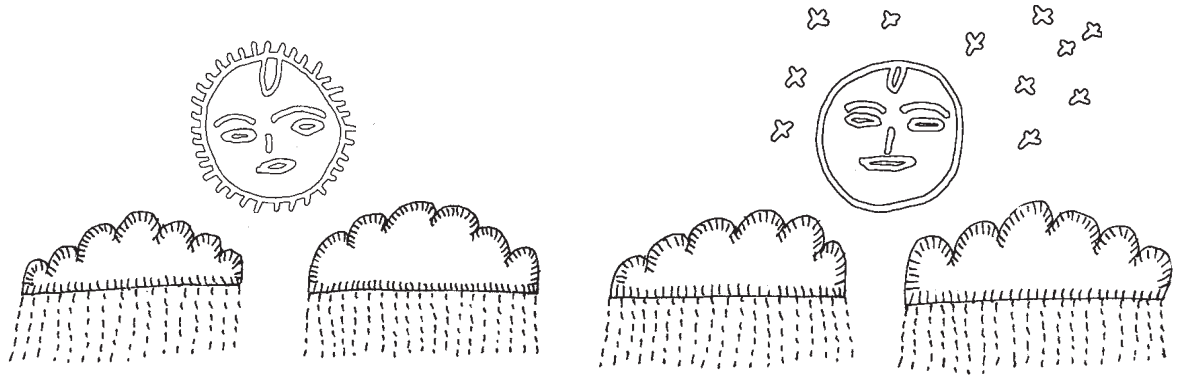
Enthusiasm in doing activities
You have shown a lot of interest in doing the experiments.

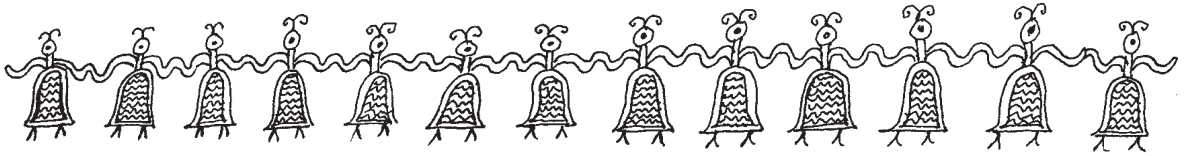
Patience and concentration
You have excellent concentration when drawing or making things - but less patience for writing.

Independent thinking
This is your strong point.

Co-operation with other students
You need improvement here - let other students in your group help instead of trying to do everything yourself.

Completion of home assignments
You were very diligent in measuring the evaporation of water and in doing other homework assignments.





UNIT 1

SKY AND WEATHER

Chapter 1 Sun, wind, clouds and rain

Chapter 2 Day sky, night sky

UNIT 1 Sky and weather

AN OVERVIEW

Objective

To observe phenomena related with the sky and weather and relate these with ones' daily experiences:

1.1 To know, observe and describe common indicators of weather (sunlight, clouds, temperature, wind, rain and humidity)

1.2 To keep a daily record of the local weather through the year and infer some seasonal variations

1.3 To observe the sky/ weather in different seasons and times of the day and to record the data in pictures, tables and charts; to understand the use of a calendar

1.4 To recognise variation in temperature through the day and to plot picture graphs of temperature

1.5 To construct an indicator of wind direction and to get an intuitive idea of wind speed

1.6 To measure rainfall in cm. and record it on picture graphs

1.7 To get an intuitive idea of 'humidity' (to be connected in later Units to the presence of water vapour in the air, and the water cycle)

1.8 To become aware of the annual cycle of the seasons through observations of natural phenomena as well as social happenings

1.9 To observe sunrise and sunset; to use these times to calculate the length of the day and night

1.10 To observe that the days are longer in summer than in winter while the nights are shorter

1.11 To observe shapes of shadows and to measure the change through the day in length and direction of shadows due to sunlight

1.12 To observe moonrise and moonset; to draw the cycle of moon phases and to relate these with local festivals

1.13 To observe the night sky and to recognise a few constellations and if possible, planets

1.14 In all of the above, to practice skills of measurement, estimation and working with the hands, cutting, pasting, constructing, etc.

What is new in this Unit

This Unit is based on observations of the sky and of weather. One problem with the observational approach in a tropical country like India is that day-to-day weather and daylight variations are small. However by selecting the right times of the year, variations in weather can be observed easily. Just before the monsoons students could watch sunny, clear skies and white clouds, then as the monsoons approach, they could observe the changes in the sky, in temperature, and in wind conditions.

Students have learnt in earlier classes about summer, winter and the rainy seasons. Though the observations in this Unit mostly deal with 'weather' rather than 'seasons', there are inferences about 'seasons' from daily observations as well as through experiences of vacations, festivals, agricultural activity, seasonal changes in plants, seasonal fruits and vegetables and variations in daylight hours. In Class 4, students should get the general idea that seasons repeat cyclically through the year. Detailed treatment of seasons is to be done in middle and secondary school.

In Chapter 2, observation-based teaching means that the sun, moon and stars are seen from an earth-centric viewpoint. Only at the end of Chapter 2 (*Did you know?*) the sun-earth-moon system is mentioned. Observations of the night sky should be done at a time of the year when the weather is not foggy or cloudy - the end of the monsoon is usually a good time.

Activities in this Unit provide good contexts to introduce measurement and graphing. While the construction and measurement/ estimation parts are fairly simple, the graphing activities might be difficult, especially in the beginning of the year when students have not developed sufficient quantitative thinking skills to tackle them. In that case the data

collection could be done earlier but some of the analysis completed later in the year after the mathematics becomes more familiar.
An important teaching aid for this Unit is a calendar. A ready-made calendar with large date cells or a large-size calendar drawn on chart paper could be hung up in the class. Events like holidays, festivals and outings marked on the calendar will add interest and meaning to the observations of the sky and weather.

Time-table

P: Number of periods

Chapter 1

P1 - Story
P2-P17 - Activities
P18-P30 - Exercises

Chapter 2

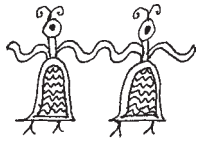
P31-P41 - Activities
P42-P47 - Exercises

Continuing observations and homework need to supplement the class work.

Materials and information to be collected for the Unit

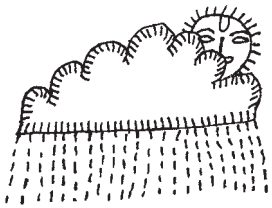
Chapter 1: Thermometer, weather reports for one week from newspaper, radio or TV; twig with a soft centre or pencil with an eraser at one end, drinking straw, common pin, piece of card paper; large bowl or thali; large plastic bottle, sharp scissors, rulers.

Chapter 2: Times of sunrise and sunset for one week in summer and one week in winter; meter scale to measure length of shadows; matchsticks, bit of thick glue or dough; observation of shape of the moon for one month; star chart for the month if possible (might be got from a star atlas, newspaper or a magazine like the *Science Reporter*).



Page number cross references

Throughout this book, **TB** refers to the TextBook and **WB** to the WorkBook.



CHAPTER 1 Sun, Wind, Clouds and Rain

STORY (1 period; TB p. 3)

The rains are coming!

It was a hot day in June. Mini and Apu were sitting in the shade eating cucumbers. "How dry and dusty everything looks!" said Mini.

"Yes," replied Apu. "Did you see the pond? The water is all gone and the floor is cracked up with the heat."

"Amma says that any day now, the monsoon winds will reach us. The winds will bring thick dark clouds. They will cover the sky, and then it will rain!"

"Ooh, that will be fun!" Apu replied, "We can get wet in the first rain. There might even be thunder and lightning ..."

Heat all around
Even leaves have stopped speaking
Then: a storm wind blows!

The sky darkens, cools
Suddenly on a dry leaf
The raindrops patter

The coming of the monsoons is a dramatic event. The story sets the scene for the poem which is in the form of two *haiku*.

> The *haiku* is a popular mystical poetic form used in Japan for three hundred years. It generally consists of seventeen syllables divided into three lines of five, seven and five syllables. These few words could paint a vivid image, evoke a mood or emotion, and suggest a meaning that goes beyond the words. A haiku generally relates to nature with reference to one of the seasons. Haiku could be introduced to students in their poetry class. It is brief and does not

require rhyming words. It could be an interesting form for students who might have limited vocabulary but do enjoy the sound of words. Some examples of haiku might encourage students to try their own. These are English translations of haiku by some Japanese poets:

Pouring floods of rain
Won't Mount Fuji wash away
to a muddy lake?
(Buson, 1715-1783)

Old pond-
and a frog-jump-in
water-sound
(Matsuo Basho, 1644-1694)

Even if the syllables are not in the 5-7-5 pattern, the style of the haiku is distinctive.

Here are some haiku written by primary school students on seeing fish in a tank:

What is that?
A blue twinkle, a rush of wings . . .
Aha! A fairy!
(Shana, age 10)

A stone in the water
suddenly the stone moved inside
It scared me
It was a black fish!
(Rubia, age 9)

ACTIVITIES

Watching the weather (TB p. 4, WB p. 3)

1. The weather (1 period)

a. Look out of the window. Answer these four questions in your Work-Book on page 3:

(i) Is the sky cloudy or clear?
(ii) Is the weather warm or cold?
(iii) Is it windy or calm?
(iv) Is it rainy or dry?

When you answer these questions, you describe the weather for today. Was yesterday's weather similar or different?

Classroom experience

The first few activities are aimed at developing observation as well as language. Simple descriptions of the weather helped introduce some terms and phrases like, "warm and cloudy with a little wind; no rain."

b. Complete this story. Wherever you find a △ add descriptions related to the weather. You might describe the colours in the sky, the shape of the clouds, whether and how the clouds were moving, the heat, cold and the effects of the weather on plants, animals and other things.

It was a beautiful Sunday morning . . . △ . . . Mini and Apu went outside. They saw . . . △ . . . They decided to fly a kite . . .△ . . . Suddenly . . . △ . . . (What happened next?)

After telling the story, write a title for it on page 3 in your WorkBook.

Classroom experience

Here the descriptions of weather were more detailed as the students recalled observations and used their imaginations. In building up the story of Mini and Apu's play with the kite they used a series of vivid images like, blue sky, sunlight, birds, heat, sweat, wind drops suddenly, trees blow in wind, sky darkens, smell of wet soil, sounds of thunder and rain, frogs and earthworms, etc.. All the students contributed enthusiastically to the story. No writing was required.

2. Weather calendar (2 periods + continuing observations; TB p. 4)

Practical hints

It is sufficient to record the weather for about 4 weeks. In case the observations start during one month and continue into the next, students should do the first month on pages 4-5 of the WorkBook and continue into the next month on pages 6-7.

a. A design of a calendar is given on pages 3-7 in your WorkBook. Fill in the year and the month. Write the dates in the boxes.

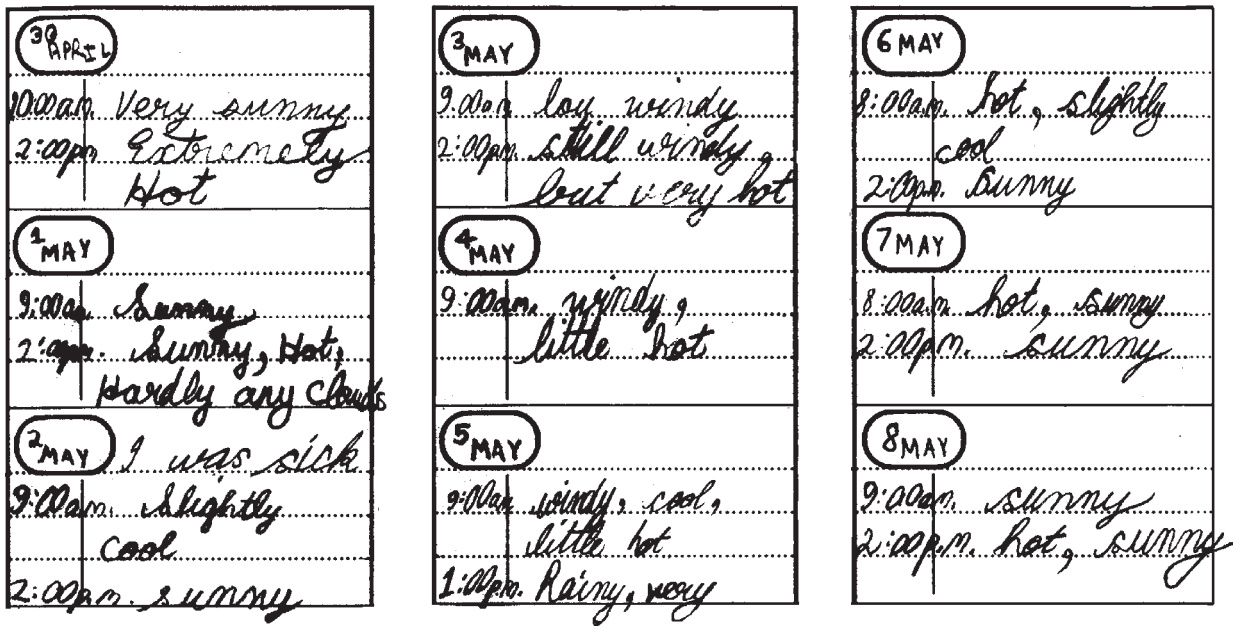
b. Observe the weather every day and fill it in the calendar. At the top of the date box note any other important happenings of that day.

Classroom experience

Part a. (writing dates on the calendar) was done in class. Part b. (observation and writing) was done by students on their own. Initially they tended to forget, to write carelessly or to copy from their fellow students. I appointed four students, who were themselves regular in observations, to remind the others in their row. As they proceeded with Activities 3-8, their observations in the calendar also improved.

Special events enabled students to recall that day better. These were personal events (e.g. brother's birthday or visit of guests) or holidays/ festivals, like, 'Independence Day' and 'Raksha Bandhan', and events in the school. The girls in the class turned out to be more regular, accurate and systematic in recording than the boys.

Sample responses are shown:



3. Warm or cold (3 periods; TB p. 4, WB p. 8)

a. A thermometer measures temperature. It tells you how hot or cold something is. Find a thermometer that can measure the temperature of air around you. Does the temperature change through the day?

We measure length in metres, weight in kilograms and time in seconds. How do we measure temperature?

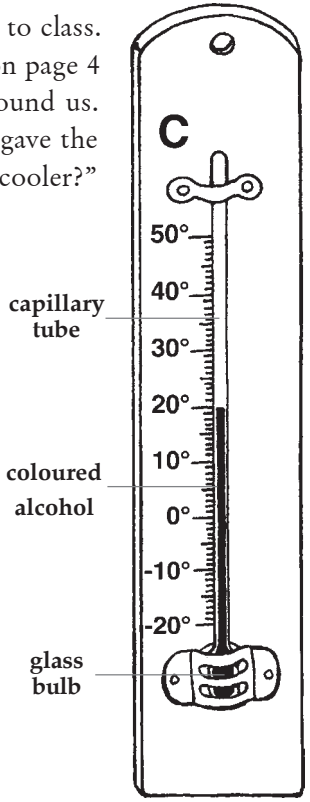
Classroom experience

Most students had seen a clinical thermometer; some brought one to class. I told them that a similar thermometer (shown in the illustration on page 4 of the TextBook) was used to measure the temperature of air around us. The comparison with body temperature was also useful because it gave the students a reference point: "Is this thing hotter than our body or cooler?"

A **common thermometer** consists of a small thin-walled glass bulb attached to a thicker-walled closed capillary tube and filled with mercury or coloured alcohol. As the liquid in the bulb expands or contracts due to temperature changes, its level rises or falls in the tube.

The scale of a **clinical thermometer** shows fractions of a degree in a small range around normal body temperature. This thermometer has a constriction which prevents the mercury from falling back when the thermometer is removed from contact with the body.

The standard unit of temperature is degrees Celsius (°C), also known as degrees Centigrade. Degrees Fahrenheit (°F) is often used in clinical



thermometers. You can convert from one scale to the other using the formula:

C/5 = (F-32)/9

Some everyday temperatures are given below:

	°C	°F
Melting point of ice	0	32
Boiling point of water	100	212
(Other temperatures - approximate)		
Freshly made tea	85	
Warm bath water	45	
An owl's body	40	
Human body with fever	39	
A normal human body	37	
Inside a refrigerator	12	
Inside a freezer	-12	
Mixture of salt and ice	-20	

Thermometers to measure air temperature are kept at the weather station in an enclosed but well-ventilated box - in the shade, protected from wind. Special thermometers are used to record the maximum and minimum temperatures in the day. These temperatures are reported in newspapers and on the radio and TV.

Apu measured the temperature at different times of the day. This is what he found. Colour the thermometers on page 9 in your WorkBook to show these temperatures in degrees Celsius (°C).

Time	Temperature (°C)
6:00 am	8°
9:00 am	12°
12:00 pm	20°
3:00 pm	24°
6:00 pm	21°
9:00 pm	18°
12:00 am	15°
3:00 am	11°

Classroom experience

The time-temperature table on page 8 of the WorkBook could be filled if students have access to a thermometer. However, since it still may not be practicable to take temperature readings through the day, sample data (Apu's data) is given.

Students found it easy to plot this data on the picture graph on page 9 in the WorkBook. Some even answered more advanced questions like, "During which times was the temperature increasing? Why? When was the air cooling? Why? When did the temperature fall the fastest?"

b. Find out the temperature for one week from the radio or TV weather report or a newspaper. Remember that today's newspaper gives yesterday's temperature.

Find out the meaning of **maximum temperature** and **minimum temperature**. In your WorkBook on page 10 write each date and the maximum temperature on that date. Then shade the temperatures in the graph.

Classroom experience

The national newspapers and some local papers report the daily weather. Many students collected these cuttings over a few days. Although the reported weather was for the nearest city, we were able to use the cuttings for the activities on temperature, rainfall, sunrise /

sunset and moon watch. The fractional part of the temperatures caused some problem as students were not familiar with fractions or the decimal-point notation. I showed them how to round off the temperature readings to the nearest whole numbers of degrees. They plotted these numbers in the graph on page 11 of the WorkBook. The graph was an almost horizontal line, showing that the day-to-day variation in maximum temperature was small. Some students also listened to the weather report on radio or watched it on TV. The TV reports helped them get familiar with the map of India and the variation of temperatures between the major cities. They could tell, from the temperatures in°C, whether that place was hot, warm, cool or cold.

Sample data for maximum and minimum temperatures for New Delhi in January are given below. (During the same period the maximum and minimum temperatures at Mumbai were around 34° C and 21° C respectively.) In case the students do not succeed in collecting temperature data from newspapers, this data might be used for the graph on page 11.

Date	Maximum Temp.(°C)	Minimum Temp.(°C)
01-01-1997	24	6
02-01-1997	22	6
03-01-1997	22	6
04-01-1997	22	5
05-01-1997	23	5
06-01-1997	23	7
07-01-1997	24	6

4. Which way the wind blows (2 periods; TB p. 5)

Students described their experiences of a breeze: (with a gentle breeze) kite-flying is easier, clothes dry faster, windmills work, boats sail ... (with a strong wind) clothes and grains set out for drying fly off, leaves and garbage fly, dust goes into your eyes, doors bang shut,

etc. These are all qualitative observations of wind speed. A formal understanding of 'speed of an object' is not possible for students at this age. 'Wind speed' is an even more difficult idea; besides, the measurement of wind speed is difficult too. The activities therefore focus on wind 'direction' only and not on 'speed'.

a. Crush a dry leaf and throw up the pieces. See if the wind blows them to one side. Can you tell which way the wind is blowing?

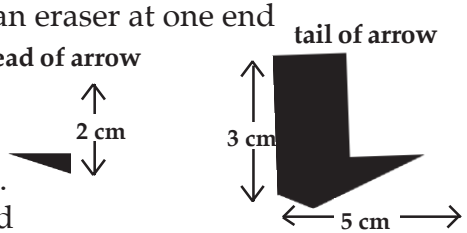
This is a very simple method for telling the direction of the wind. We found this method also useful to crosscheck the wind direction while testing the wind vane in **b**.

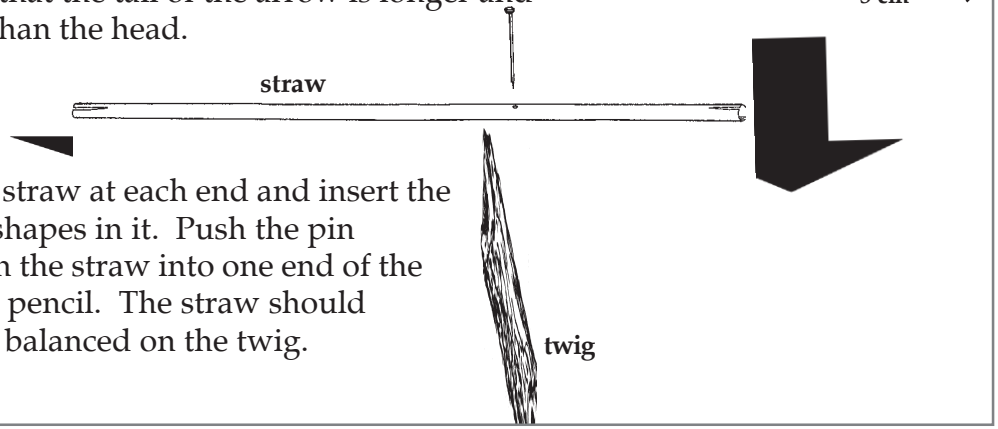
b. Make a wind vane to tell which way the wind is blowing (TB p. 6, WB p. 12).

You will need:

- a twig with a soft centre **or** a pencil with an eraser at one end
- a drinking straw
- a pin
- a piece of card paper

Cut these arrow shapes from the card paper. Notice that the tail of the arrow is longer and wider than the head.

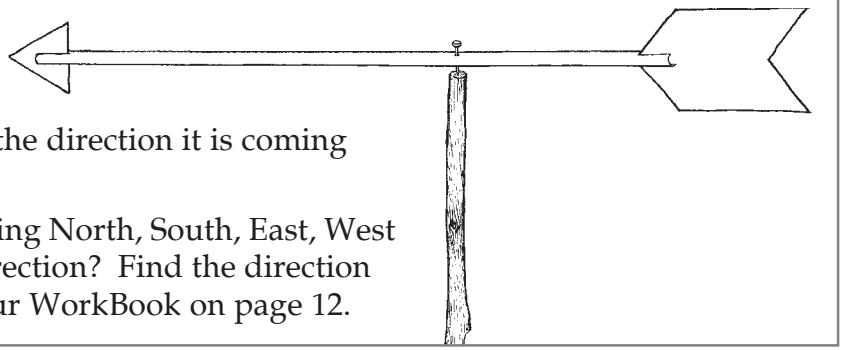




Slit the straw at each end and insert the arrow shapes in it. Push the pin through the straw into one end of the twig or pencil. The straw should remain balanced on the twig.

This is your **wind vane**. Take it outdoors and hold it in the breeze.

Is the arrow pointing in the direction that the wind is going, or the direction it is coming from?



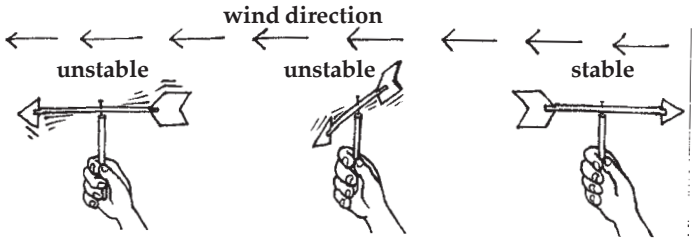
Is the arrow pointing North, South, East, West or in any other direction? Find the direction and write it in your WorkBook on page 12.

Classroom experience

Students made the wind vane easily. Some who did not have the right kind of stick or pencil with attached eraser used other ideas, like, an eraser stuck on the point of a compass or of a pencil, or a pin hammered into wood. The only slight problem came while balancing the vane. With one of the arrow shapes heavier than the other, the balance point was away from the centre of the straw. The wind indicators worked well outdoors - all of them pointed into the direction of the wind. The directions (N, S, W, E) were discussed later.

Practical hints

Various shapes for the wind vane are possible, but one of the ends should be broader (have larger area) than the other. In fact only the wide tail of the arrow is essential - the small arrow-head could be dispensed with. In a breeze the broad end swings away from the direction that the wind is coming from. This is the only stable orientation of the wind vane. For a short while it might be possible for the broad end of the vane to point into the wind, but this position is unstable. Any little movement makes the wind push the vane back to the stable orientation.



Students' responses

Back in the classroom we discussed the direction of the wind. I realised then that there was utter confusion in students' understanding of directions. They had learnt the terms, East, West, North and South, in their Geography class last year. Yet some students said that the four directions were, front, back, left and right. Others thought that North was always ahead of us, South behind, East on the left and West on the right! One student confidently said that North was up and South was down, near his feet.

It needed some discussion before students recalled that the sun rose in the East and set in the West. They remembered where they saw the sun while coming to school and from which window the sunlight entered the classroom every morning. Once these directions were established they realised that the arrow had been pointing West: the wind was blowing from West to East.

I explained that we refer to the **wind direction** as the one that the wind is **coming from**. An **East wind** means wind that is blowing from the **East**; the **Southwest monsoon winds** blow from the **Southwest** of India, and so on. Winds may bring about a change in weather which depends on which direction they blow from; for example, cold winds from the Himalayas in the North may bring about a 'cold wave' in other parts of India.

5. The wind makes waves (half period; TB p. 7, WB p. 12)

Take a large bowl or thali full of water. This is your 'ocean' and you are the 'wind'. Blow across the water gently but continuously.

Float a small leaf on the water and blow again. Draw a picture of the 'storm in the ocean'.

This activity was done in groups. Besides using dry leaves students also made paper boats for their 'ocean'.

6. Sky and clouds (2 periods + home-work)

Do these activities on four different days (see WorkBook page 13):

a. Watch the sky for clouds. Write down some words to describe the clouds. You can describe: the colour of the clouds, how big they look, their shapes and how much of the sky they cover. Draw the shapes of the clouds as you are looking at them. Do the shapes change?

b. Watch the colour of the sky. Is it always blue? Is the entire sky of one single colour? Does the colour of the sky change from day to day? Describe how the colour changes through the day - in the morning, afternoon, evening and night.

Classroom experience

Observing, describing and drawing the sky turned out to be quite a challenging activity. In the preparatory classroom discussion students said that the colour of the day sky was blue, white or both blue and white. This was accurate as in the previous few days the sky has been white with a high layer of white clouds, with more grey and white clouds lower down. The students did not realise on their own that the higher layer was clouds and not 'sky'. In cities it is also common, even without clouds, for the sky to be white due to a haze. Surprisingly, for 'colour of clouds' the responses were, in addition to white, grey and black, also 'blue'. I later heard this response from other young children too.

The drawing task was initially difficult as the scene in the sky was quite complex. I asked the students to look in one particular direction and to write, say 'East', at the top of their drawing.

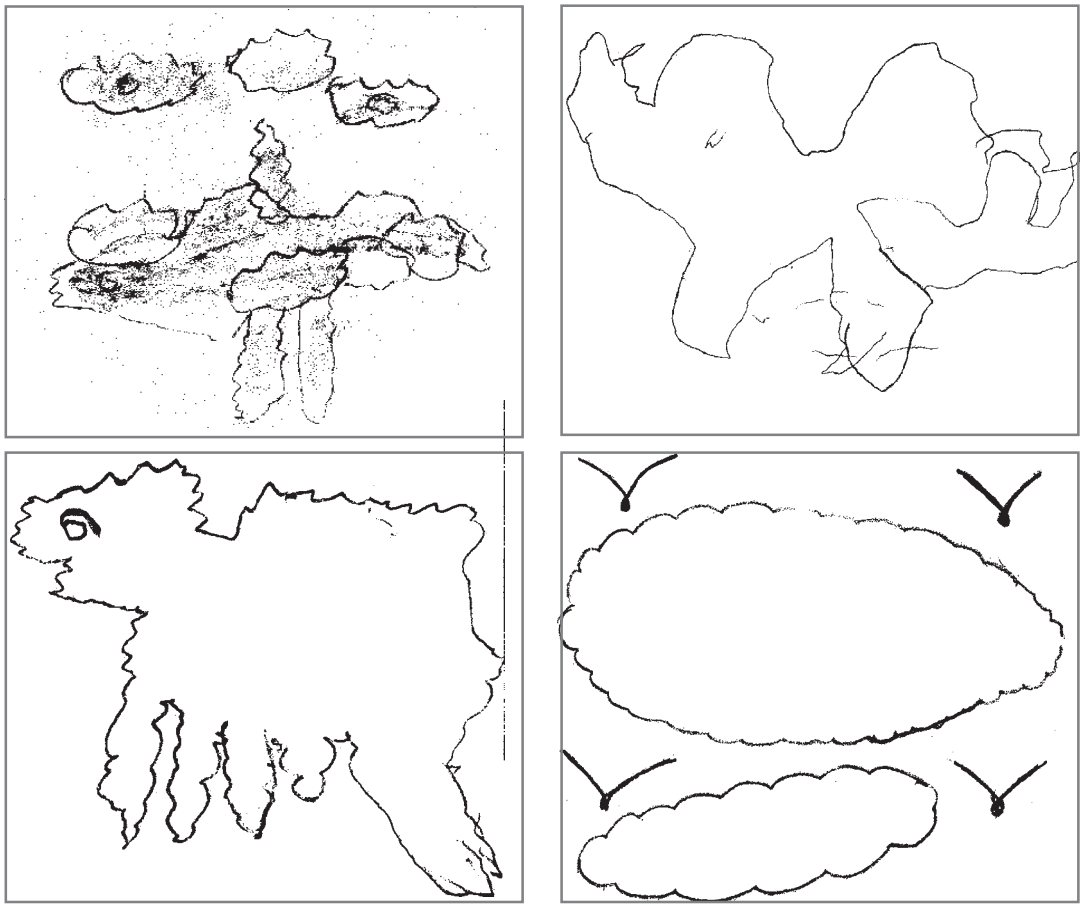
Before they went outdoors for observations, I wrote the following points on the board:

Direction (East / West / North / South)
colour of the sky
number of clouds
size (small / big)
patterns, shapes and colours of clouds
clouds moving or stationary

The observations and drawings for the first day took up two periods. The remaining days were assigned as home work.

Students' drawings and descriptions:

East - Sky was white. Three big grey clouds were moving. Shapes of the clouds were changing. One small cloud slowly disappeared.



Clearly, unlike the first 3 pictures,the last one was made by a student who was not looking at the clouds.

Think! Think!

What do you think clouds are made of?

What makes clouds move in the sky?

Students' responses

These questions are meant to make students think and make their own guesses before some of the answers are given to them later. Here they can take the freedom to think of their own answers instead of just trying to remember the "right" answers. Indeed one student came up with an interesting response:

"I think clouds are made of dried rain."

This student had captured the essence of the water cycle in her own way: that clouds come from evaporated (dried) water that comes from rain!

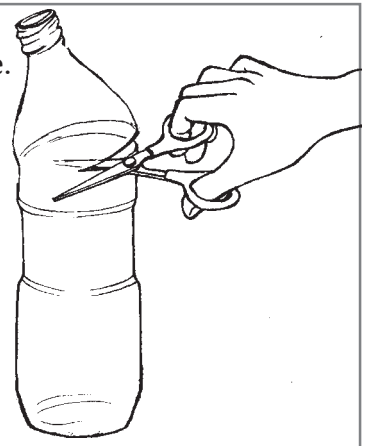
Such questions may also bring out misconceptions, but even these responses lead to progress in thinking. I have found students, even in Class 6, think that clouds are living - many of their 'criteria for living things' apply to clouds! Students in my class thought that smoke goes up to make clouds but then wondered how rain could fall from clouds made of smoke. There was some confusion about whether clouds are made only from water vapour and whether water vapour is white or colourless (see the discussion in Chapter 5, page 177).

7. Measure the rain (2 periods + continuing observations; TB p. 8, WB p.14-16)

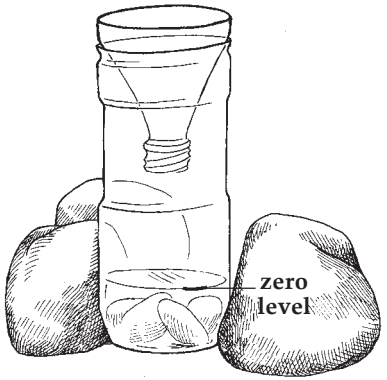
During the preparatory discussion students mentioned that rain water gets collected in ponds and lakes and that the level of the pond rises with more rainfall. They realised that some of the water would sink in the soil and perhaps later enter the pond via the soil (this is the important concept of ground-water which we discussed later, in Chapter 7). One student thought of putting a stick in the pond to see how much the level had risen. They also suggested measuring rainfall by collecting rain water in a bucket, drum, oil tin or glass.

I drew several possible containers on the board. Intuitively students realised that a container with upright sides would be preferred. The meaning of 'cylindrical' and 'upright sides' was clearer after the students brought some containers of various shapes. I discussed the first question in *Figure it out* here and found much confusion (see page 57). After the activity we discussed the questions again.

a. Find a large plastic bottle. Cut off the top and invert it into the lower part. This is your **rain gauge**.



If you cannot find a bottle, use any tins or jars with upright sides. Put some stones in these containers. Add enough water to cover the stones. Mark the 'zero' level of water.



Keep the containers in different places out in the rain - for example, on a terrace, or in an open ground. Support the containers with stones or bricks. Make sure that rain can fall into them freely. Note the date and time on page 14 in your WorkBook.

Each day, measure how much the water level has risen in your container. Note this measurement in the Table and Graph in your WorkBook on pages 14-15. Empty the container back to the zero level.

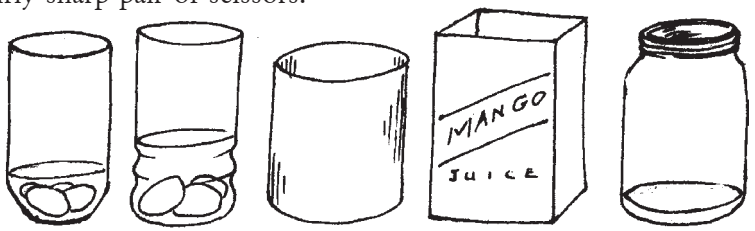
Did the water level remain unchanged on any day?

Did the water level decrease on any day? Guess why.

Was the change in water level about the same in every group's container?

Classroom experience

We did not find any exactly cylindrical containers. Where the bottom was curved, we added a few stones and some water up to a point which we then marked as zero level. The heavy stones also made the container more stable. The plastic bottle with inverted funnel shape was useful to keep the water from evaporating. For cutting the plastic bottles we needed a fairly sharp pair of scissors.



We kept the rain jars outside for the whole week, checking the level every morning. We made sure that the rain was not blocked by walls, trees or buildings. On some days the water level rose by up to 4 cm.. There was a difference of up to a centimetre in the amount of water collected by different groups. Even rain gauges kept close together showed slightly unequal water levels. Students suggested that the water might be splashing or getting blown in or out by the wind. Others thought that the rainfall might not be exactly the same everywhere.

Practical hints

Resetting the container to zero-level every day needed some practice. I asked students to pour out more water than necessary and then to slowly add water to reach the zero level. Imperfect matching with the zero level might also have led to some error in measurement.

Sometimes part of the day was quite sunny. One student asked, could some of the water have dried up before we checked it? This was more likely to happen with the wider and the open jars. I suggested that we could add a drop of oil to the water. Would this stop the water from evaporating? This led to another experiment in which we kept out in the sun two identical jars with the same quantity of water, with a drop of oil added to one

of them. The drop spread out, covering the surface of water. On the next day the jar without the oil drop showed a decrease in the level of water.

In arid areas with little rainfall it might be a good idea to use a large collecting funnel and a narrow jar. The rise in water level would be artificially magnified, but it would at least give the students a chance to make some measurements.

8. Humid or dry? (1 period; TB p. 9, WB p. 16)

On some days you perspire a lot. Your wet clothes stay wet for a long time. These are humid days.

On other days your skin feels very dry. Wet clothes dry soon. These are dry days.

Try to guess which days are very humid and which days are very dry. See if your friends agree.

Humidity is not a familiar idea for students, nor is it easy to convey. Though simple observations are useful to introduce the term 'humidity', such judgements are not very reliable. For example, the rate of perspiration and drying depend on, besides humidity, temperature and wind conditions. However some intuitive understanding of humidity is certainly possible in this way. Students might also observe difference in texture of hair and cloth in humid or dry weather. One of the ways of measuring humidity is with a 'hair hygrometer' in which the increase in length of a stretched human hair is measured (hair absorbs moisture and becomes longer).

Clouds and rain (TB p. 9)

Clouds are made up of tiny drops of water. They move with the wind.

When clouds cool, the water drops in them come together to form bigger drops. These drops are very heavy, so they fall down. We call it rain.

Sometimes pieces of ice fall with the rain. This is called hail.

In very cold places in winter, white flakes of snow fall down instead of rain.

Linkage across topics

This section in the TextBook gives some basic information that the students can relate later with the Units on Air, Water and Food. Additional information given below might be useful to answer some questions which students might ask.

With the heat of the sun, some water on the earth's surface turns into water vapour. This water vapour rises up on a current of warm air. As it rises, it cools and condenses on tiny particles of dust, smoke or salt in the air, forming little water droplets. On cold winter nights such cooling can take place close to the ground and we get a (light) mist or a (dense) fog. If the cooling happens high above the ground we get a cloud. You could walk into a cloud by climbing a mountain. Here a cloud might pass right around you and it would look and feel like a mist or fog.

How are raindrops formed out of little water droplets? The particles of dust on which water droplets begin to form on are as small as a few millionths to a few thousandths of a centimetre. Air currents inside the clouds keep these little droplets constantly circulating up and down. In moving they collide and often combine with other water droplets, so growing bigger. When their size reaches about a tenth of a millimetres they fall down as drizzle. Normally a raindrop has a diameter of few millimetres while a hailstone is a few centimetres in diameter.

Why don't clouds fall down? The total weight of a medium-sized cloud could be several hundred-thousand tons. Water is about 800 times denser than air so water droplets could never float on air. The fact is that the droplets do fall under gravity but due to air resistance they are slowed down so much that they appear to float. They are also pushed up by air currents inside the cloud. Larger drops are slowed down much less and so they manage to fall to the ground.

Clouds are of different shapes depending on how they are formed. The large cauliflower-shaped clouds with a flat base (called cumulus) are formed at low heights (up to 2 km) by upward-moving currents of warm air. These clouds are constantly changing shape due to strong air currents and the continuous condensation and evaporation of water droplets going on inside them. Layer clouds (called stratus) are formed at different heights by horizontal mixing of warm and cold air. In passing over a mountain range they can assume wavelike shapes. Feathery or hair-like clouds (called cirrus) are formed at heights of more than 8 km and are made largely of ice crystals.

Weather is important for farming

To plant crops we need rain. Seeds need water to sprout. Crops need water to grow.

But if it rains at harvest time, crops can be damaged. Rain can damage grain and fruit. Groundnuts rot in wet ground. Cotton bolls get wet and dirty.

Weather is important for every aspect of farming, starting from ploughing, through the growth of the crop, to harvesting and storing of the grain. Rainfall is the major factor affecting all this. The amount and distribution of monsoon rainfall over the country has an effect of agricultural yield which in turn affects the whole economy.

In Northern India there are two cropping seasons, *kharif* (July to October - period of the south westerly monsoon) and *rabi* (October to March - post monsoon). Crops grown between March and June are known as *zaid*. The cropping seasons vary somewhat in different parts of the country. Examples of *kharif* crops are, rice, jowar, bajra, maize, ragi, groundnut, cotton and tapioca. Some *rabi* crops are, wheat, jowar, gram, oats and barley. *Rabi* crops depend on moisture remaining in the soil after the monsoon, supplemented by irrigation.

Major droughts and floods occur every season in different regions. If a break of a few weeks in the monsoon comes early in the growing season, say in July, then crops are damaged. Hailstorms which occur mostly in February or March over Central India are also harmful. If cloudy weather persists during the flowering season, pests and diseases multiply. Extreme hot or cold weather over a long period can also damage crops.

Know these words

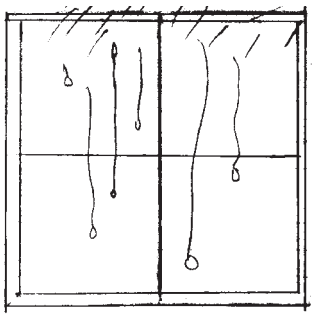
weather	thunder	breeze	hail	flood
monsoon	lightning	gale	mist	drought
		storm	snow	
			fog	

EXERCISES (13 periods + home-work)

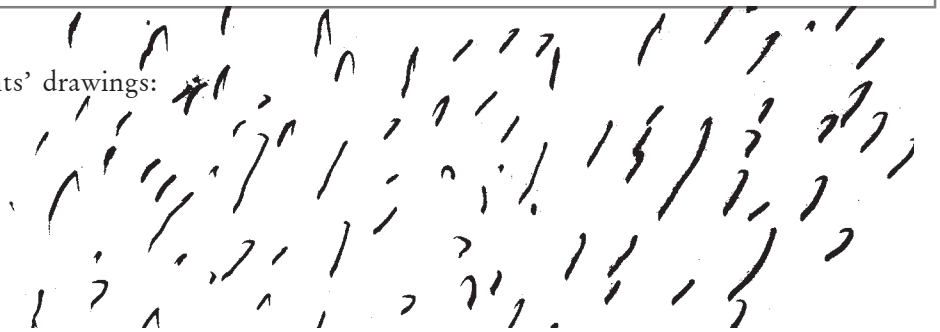
Observation-based exercises

Name and draw (WB p. 16)

1. Rain

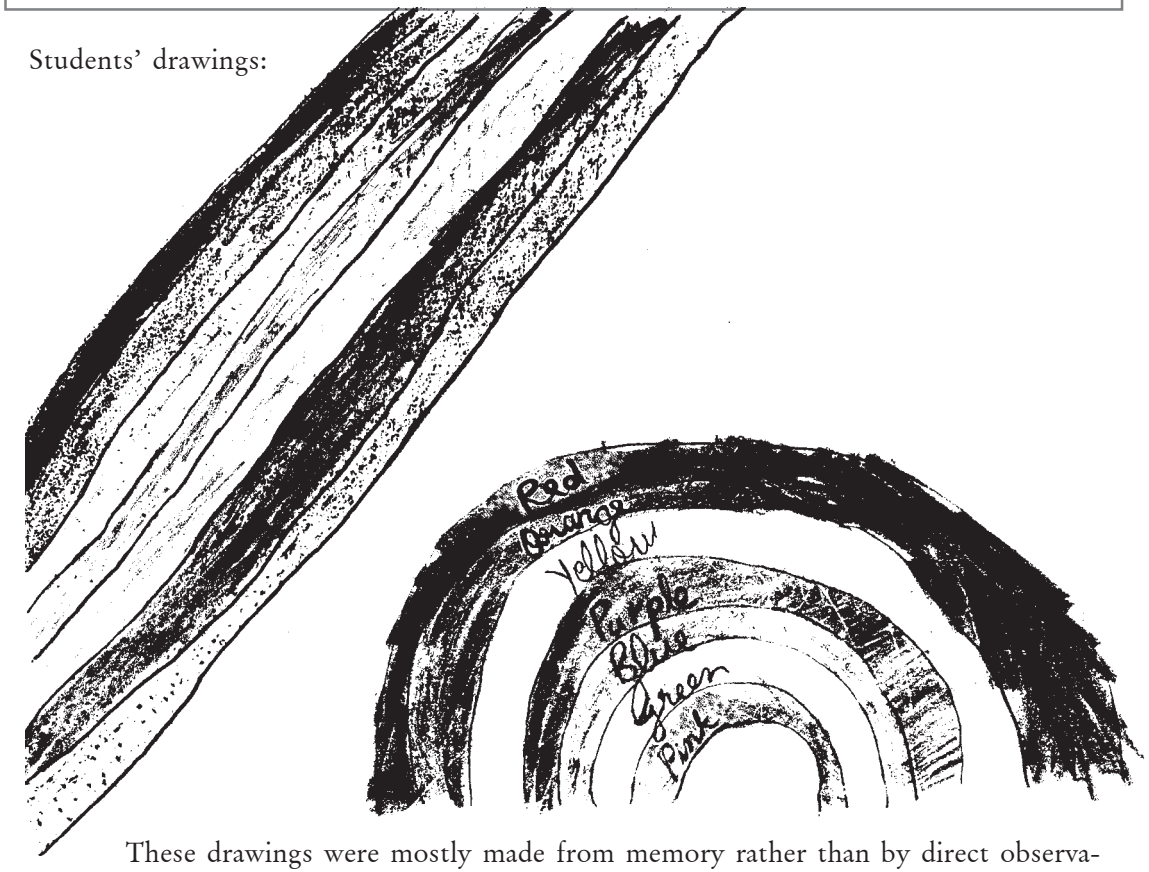


Students' drawings:



2. Colours of the rainbow

Students' drawings:



These drawings were mostly made from memory rather than by direct observation. Some students had learnt in previous classes the colours of the rainbow given by VIBGYOR. Some knew that it is rare to see all the colours in a rainbow but nonetheless they wanted to show all seven colours in their drawing. I had to remind them that violet was on the inner side of the arch.

Interesting questions (WB p. 20)

Answer questions 1-4 after completing the chart on pages 18-19 of your WorkBook.

Classroom experience

I put up in the classroom an enlarged copy of the chart in the WorkBook: 'Weather for the year'. This chart was filled daily through the year by students with some help from me. Often there was no single correct way of colouring the box, with minor disagreements on whether a particular day was hot/ cold, or just pleasant. Weather could also change through the day. Still, taking the month as a whole, these judgements did not differ much. If students forgot to fill their chart daily they had a chance to copy it from this classroom chart. (In case this year-round chart activity becomes difficult to sustain, questions 1-3 might be answered by asking adults.)

1. In which months of the year do you have winter?
2. In which months of the year do you have summer?
3. In which months of the year do you have a rainy season?

Students wrote the winter months as November to February, summer as April to June and October, and rainy season as June to August. There may be variations according to the region.

4. In which month do you have school sports, outings or picnics? Why?

In most parts of India summers are very hot and winters are pleasantly cool. Sports, outings and picnics are organised during the season when the weather is pleasant and dry, usually November or December. The time may vary according to the region.

5. Name some fruits and vegetables that we get in winter and in summer.

With the advent of new cultivation and preservation techniques and also improved transportation, we find, especially in cities, many fruits and vegetables available during most seasons.

Still, some winter / summer products can be named, e.g.

Winter: carrots, peas, cauliflower, radish, spinach and other leafy vegetables, apple, strawberry

Summer: pumpkin (lauki), bhindi, cluster beans, mango, jackfruit

Rainy season: custard apple (sitaphal), guava, drumsticks

(See also *Interesting questions* in Chapter 8 (page 281) for seasonal foods eaten on certain festival days.)

6. On what kind of day (hot, cool, cold, wet, etc.) would you wear clothes made out of: cotton, nylon, wool or plastic?

Type of day	Type of materials we could wear
all days	cotton
cool or cold	nylon & wool
rainy	plastic

7. Which of these things happen when the temperature is low?

- ☐ butter is soft
- ☑ you feel cold
- ☐ you sweat a lot
- ☑ coconut oil becomes solid
- ☐ you wear thin clothes

Students also mentioned a number of other experiences of winter, including eating carrots, 'revdi', 'til' ladoos and groundnuts. Some had not seen coconut oil but knew of other hair oils which are usually based on coconut oil and solidify in winter.

8. Write down some things that happen on a very hot day.

Students' responses: land gets heated, water gets heated and turns into vapour, we wear cotton clothes or very few clothes, bathe with cold water, drink water from matka/ fridge, we feel thirsty, we sweat, have cold drinks, eat ice-cream, get burns if we walk outdoors without chappals, get tan, people faint, sun shines for a longer time – rises early and sets late, humidity increases ... they wrote some of these things also in their Summer chart in the WorkBook (page 26).

9. Write down some things that happen on a rainy day.

As in the previous question, students gave a wide range of imaginative responses.

10. Which of these things would you **not** do on a rainy day?

- ☐ swim in a river
- ☐ graze the cattle
- ☐ write a letter
- ☐ play outdoors
- ☐ do some cooking
- ☐ wash a lot of clothes

11. Which of these things happen best on a windy day? (tick)

- ☐ boats sail
- ☐ rivers flow to the sea
- ☐ windmills work
- ☐ cloths dry faster
- ☐ birds fly

There are many different correct ways of answering the above two questions. Answers depend on other circumstances (needs, opportunities, interests, wind direction, etc). These kinds of questions are useful to stimulate thinking and discussion, rather than just to check comprehension.

12. Name some ways in which wind is useful to us.

Besides responses like sailboats, windmills etc., students mentioned cool feeling due to breeze and rain clouds travelling with the wind.

13. Name some things that happen in a storm.

This was done with *Talk and write* (page 54).

14. In what kind of weather is it dangerous for fishermen to go fishing in the sea?

In a storm or cyclone, on a very windy, rainy, or foggy day.

Observation and language based exercises

Classroom discussion (WB p. 24)

1. Which time of the year do you think has the best weather? Why do you think so?

The time of 'best weather' would change from place to place. Also varied are students' ways of deciding which weather is the best.

2. How do different animals behave on a very hot or a very cold day? Are they quiet or active? Do they look for shelter?

Extremes of temperature may lead animals to inactivity. On hot days one finds animals looking for shade and water - students had seen dogs panting with their tongues held out. On cold sunny days many mammals and reptiles like to sit out in the sun.

3. What is a flood? Have you or your parents seen a flood? Have you heard of floods in other places? When and where did these floods take place? What were the reasons for the floods? What happened then?

Students talked with their parents about floods that the latter had seen or heard about, in places like the Andamans, Kerala, Patna and Assam. Recently there had been a cyclone in Orissa described as the worst of the century. Students also remembered TV pictures of

floods in Tamilnadu and Bangladesh. In some places there was a river that had got flooded, in other places it was rain water or sea water. Certain low-lying areas regularly got flooded.

Students had found out that when water flows fast it carries many things with it: roads, houses, trees, animals and people can get washed away in a big flood. Plants and bodies of animals rot (decompose). All water gets muddy and dirty. Many diseases can spread if people drink dirty water, or if mosquitoes and flies multiply. Later, in the Unit on Water, students found out some names of these diseases.

They found out that cyclones and other floods could be predicted. They discussed ways of preventing flood, like, building bunds and dams on streams and rivers; digging tanks to collect water which can be used during times of less rain; providing canals or pipes for water to flow safely to places which need water or to the sea (i.e. drainage); planting trees on hill slopes and river banks; cleaning drainage channels regularly so that they do not get clogged.)

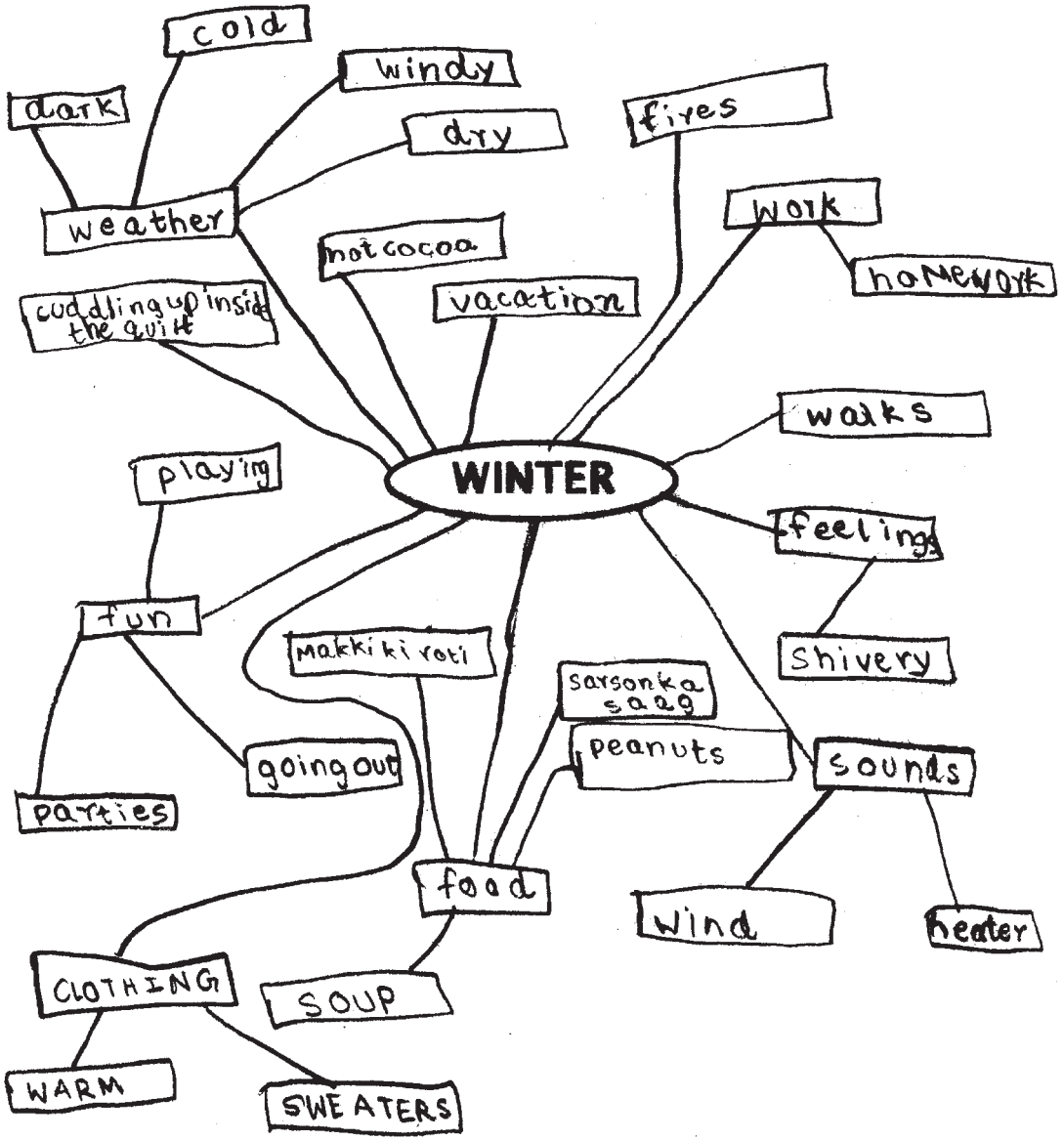
4. What is a drought? Have you or your parents experienced a drought? Have you heard of droughts in other places? When and where did these droughts take place? What were the reasons for the drought? What happened then?

Students had not heard of 'drought' before, but by asking their parents they found out the following information: the weather is very hot, there is no rainy season for a long time, land gets dried and cracked, animals and plants die, crops also dry up and there is scarcity of food as well as water. One girl's father had seen a severe drought in Orissa. People and animals grew thin and died. The Government tried to supply food and fodder. I told them that in the Unit on Water we would discuss ways of preventing drought.

What's the same? What's different? (WB p. 26)

1. A chart describing summer is given in your WorkBook on page 26. Complete it. Make a similar chart for winter.

Sample chart for winter



Talk and write (WB p. 28)

1. Remember some poems or songs about any of the seasons. Make up some new ones of your own.

Students remembered some poems, largely from their literature texbooks, and songs from Hindi movies. The majority of the songs had to do with rain or the monsoon season, some were about spring 'basant', and a few on fall or 'patjhad', which is a clearly recognisable season in very cold regions. Songs about winter and summer were rare, although there were some describing the cycle of seasons.

> Seasonal references occur often in Indian folk songs and popular poetry. The monsoon season is most frequently sung about, naturally because it is the most important season in Indian social, cultural and economic life. English weather-related songs on the other hand, tend to be often related to summer or sunny days; references to rain have to do with ignoring/ not minding it or wishing it to end!
>
> Two Hindi poets who have described nature and the seasons are Sumitranandan Pant and Suryakant Tripathi 'Nirala'. Compositions in classical Hindustani music also relate to the seasons - there are *ragas* associated with each of the six Indian seasons (*Basant, Grishma, Varsha, Sharad, Hemant* and *Shishir*).

2. Describe a thunderstorm to your friend. Your friend will ask you some question about the thunderstorm. Answer these questions.

There had been a thunderstorm on the previous day. Students' descriptions were very vivid. The day began very calm but then the wind started, blowing leaves and garbage in circles. The wind slowly became strong, the sky got very dark, there was thunder, lightning and then the rain started, gradually at first but later it rained very hard. The thunderstorm went on into the night. In the morning they found that trees had been blown down and the roofs of some houses were damaged. Here the students also got practice in asking questions in order to obtain information.

Play with words (WB p. 28)

1. Find different words which mean **wind**. Arrange the following words from **weak wind** to **strong wind**:

   gale cyclone breeze storm

breeze gale storm cyclone

Meteorologists use some simple indicators for wind. When there is almost no wind (speed less than 1 km/hr), smoke rises vertically in the air. In a light breeze (10 km/hr) you hear leaves rustling; in a stronger breeze dust and garbage fly around (25 km/hr), large branches of trees move and umbrellas can be used only with difficulty (50 km/hr). In a moderate gale whole trees move and it is difficult to walk. A very strong gale (100 km/hr) can uproot trees, a storm could cause extensive damage while a cyclone (up to 300 km/hr) is likely to be the most destructive of all.

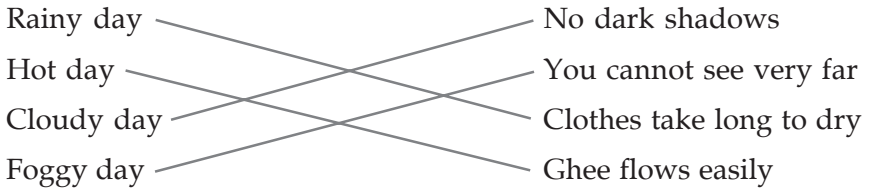
A tropical storm goes by many names: over the Indian Ocean it is known as Cyclone, in the Atlantic and Eastern Pacific as Hurricane and in the Western Pacific near China it is called Typhoon. A tornado, common in the United States and Australia, is a compact but locally highly destructive funnel-shaped system of cloud and wind rotating at 400-800 km/hr.

Khamsin is a hot, dry, dusty wind blowing from the Egyptian desert over the Red Sea. A strong wind over the Malabar coast at the end of the southwest monsoon is called *Elephanta*. Many such names exist in local languages.

2. Find words for these:

Light, fine rainfall	- drizzle
Pieces of ice that fall with rain	- hail
Fluffy frozen water from the sky	- snow
The rainy season	- monsoon
The sound with lightning	- thunder

3. Match each day with what happens on that day



Ask and find out (WB p. 29)

1. In which different months of the year do farmers sow seeds? Why?

Kharif crops are generally sown in the beginning of the summer monsoon and rabi crops before the winter monsoon. However there are variations depending on the local climate, soil, type of crops and availability of irrigation. Students would have to find the information locally.

2. Find out what the weather is usually like on any five festival days celebrated in your area.

(Varies according to region - information to be found locally)

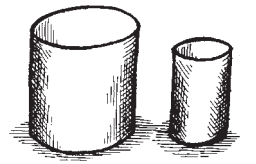
3. Have you ever heard of **lou (लू)** and **aandhi (आंधी)**? What kinds of weather conditions are these? Do you have names in your own language for unusual weather conditions?

Both terms originate in North India. 'Lou' is a very hot wind that usually blows from the West over Northern Indian plains in the months of May and June. It is a relatively even and moderate wind covering a large region of the Gangetic plain. Lou usually blows during the hot afternoon.

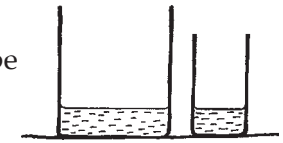
'Aandhi' is a cool, dry and often violent dust storm that occurs at the end of the summer season. It could start at any time of the day or night. It is a local wind caused by downward movement of cold air. In the pre-monsoon period it could be followed by thunderstorm and rain. In the Bengal region it is known as *Kal Baishakhi*.

Quantitative thinking

Figure it out (WB p. 29)



1. Suppose you have two containers, one wide and the other narrow. Both have upright sides. You keep them together out in the rain. Would the height of the water collected in both containers be the same, or different? Why?



2. Now suppose both containers have water up to a height of one centimetre. Would the **amount** of water in them be the same or different?

3. Suppose you keep two identical containers: one on the terrace and one in the open ground. Would they collect the same or different amounts of water?

I discussed the above three questions in class with surprising results. In Q.1 the majority of students thought that the height of rain water collected would be more in the narrow container. I asked, imagine you divide the broader container into two narrow parts by putting a thin vertical partition. Would the height of water change? To this some replied "Yes" and others "No".

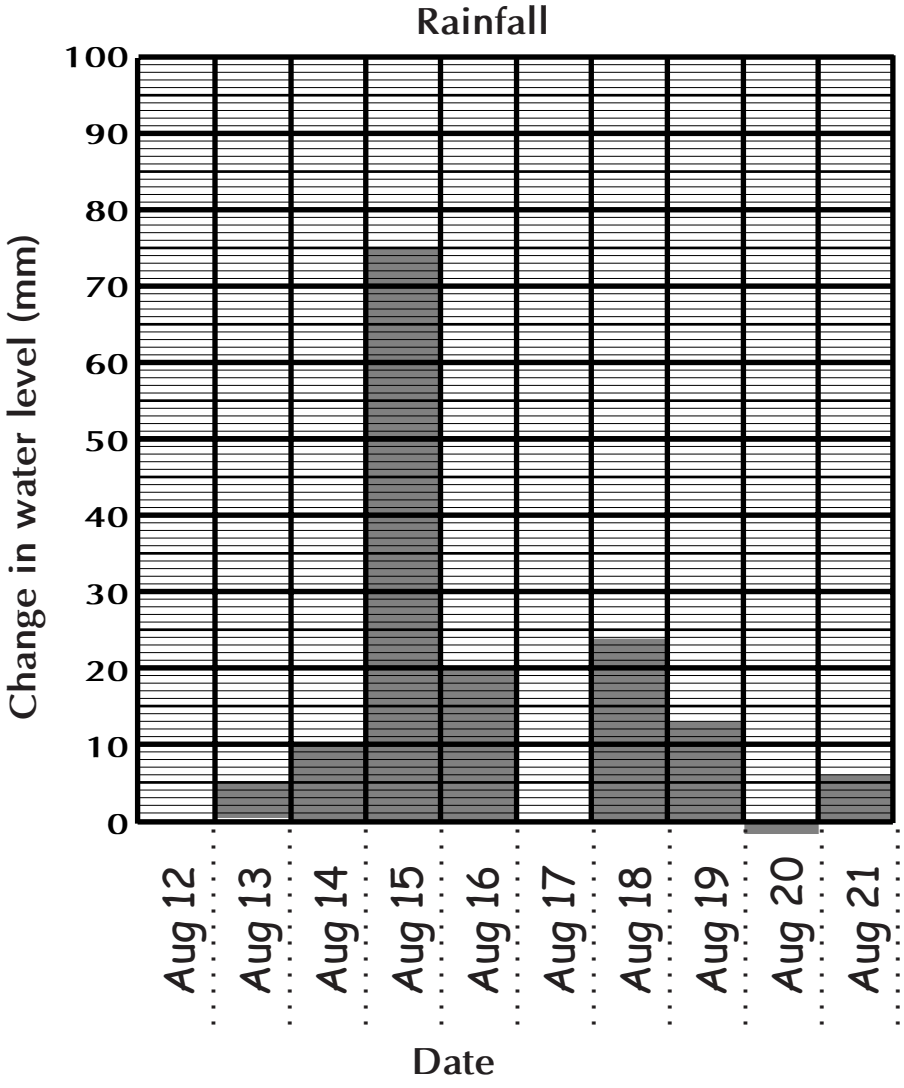
In response to Q.2 students said that if we filled both containers with water to the same height it would be the same 'amount' of water in each (e.g. two cups). It was difficult to convince them otherwise by argument. I hope that first-hand experiences as in the Class 3 Small Science book followed by the rain gauge activities and those in the Water Unit would slowly help develop these concepts.

For Q.3 we appealed to experiment. But the containers on the terrace and on the ground did not give consistent results - the water level in them differed by up to a centimetre. We discussed in class the reasons for the variation in water collected (see Activity 7 – page 42).

4. Mini and her friend Varsha put their rain gauge out on Aug 11. They measured the change in water level every day for ten days and recorded it in this graph.

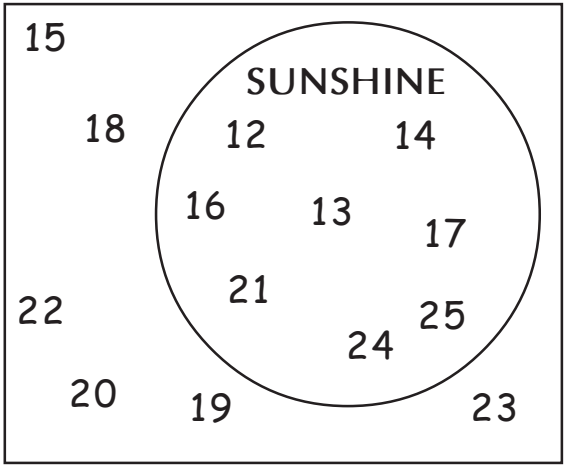
Use the graph to answer these questions:

a.How much change in water level did they find on Aug 12?	no change
b.How much rain did they record on Aug 13?	5 mm
c.How much rain did they record on Aug 14?	10 mm
d.On which days did they record 24 mm of rain?	18 Aug
e.On which days did they record the most rain?	15 Aug and 18 Aug
f.On which days did they record the least rain, or none at all?	12, 17, and 20 Aug
g.What do you think happened on Aug 20?	water evaporated or the water hadn't been zeroed
h.How much did it rain between Aug 11 and Aug 21?	152 mm
i.On which days did they record 6 mm of rain?	21 Aug


Rainfall
Change in water level (mm)
100
90
80
70
60
50
40
30
20
10
0
Aug 12
Aug 13
Aug 14
Aug 15
Aug 16
Aug 17
Aug 18
Aug 19
Aug 20
Aug 21
Date

5. Mini, Varsha and Khurshid made the weather calendar on page 33 in the WorkBook for two weeks in August. Then they made this diagram to show which days had sunshine and which days did not.

Cut out the date boxes in the calendar.



a. Sort these date boxes into two piles: **dates with sunshine** and **dates with no sunshine**.

Did Mini and her friends make any mistakes in this diagram?

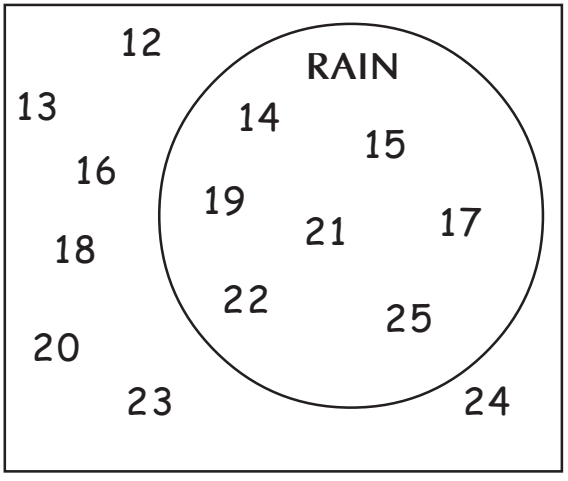
Why did they put 18 and 23 outside the circle?

They did not make any mistakes. They put 18 and 23 outside the circle because it was not sunny on those days.

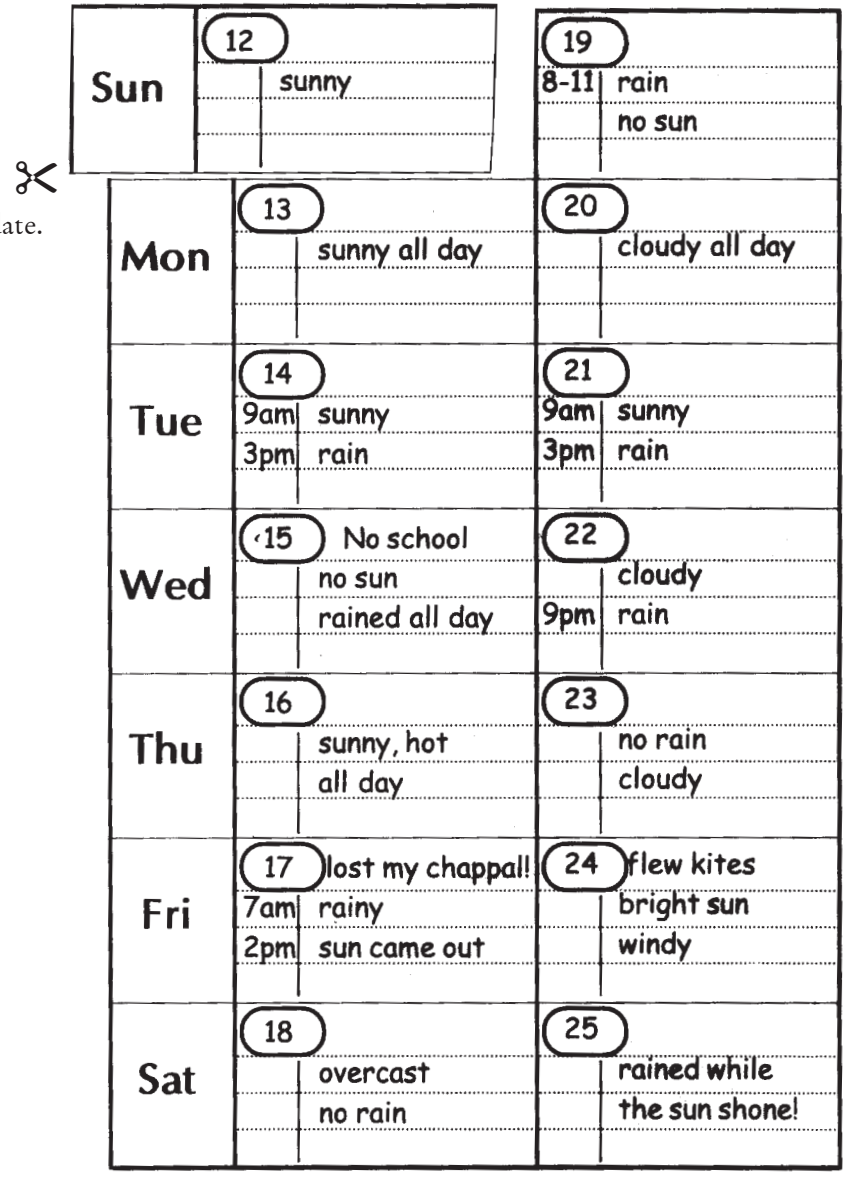
b. Now sort the date boxes into these two piles: **dates with rain** and **dates without rain**.

In the following diagram, write the dates with rain inside the circle. Write the dates without rain outside the circle.

The dates are shown in the correct positions in the diagram on the right.

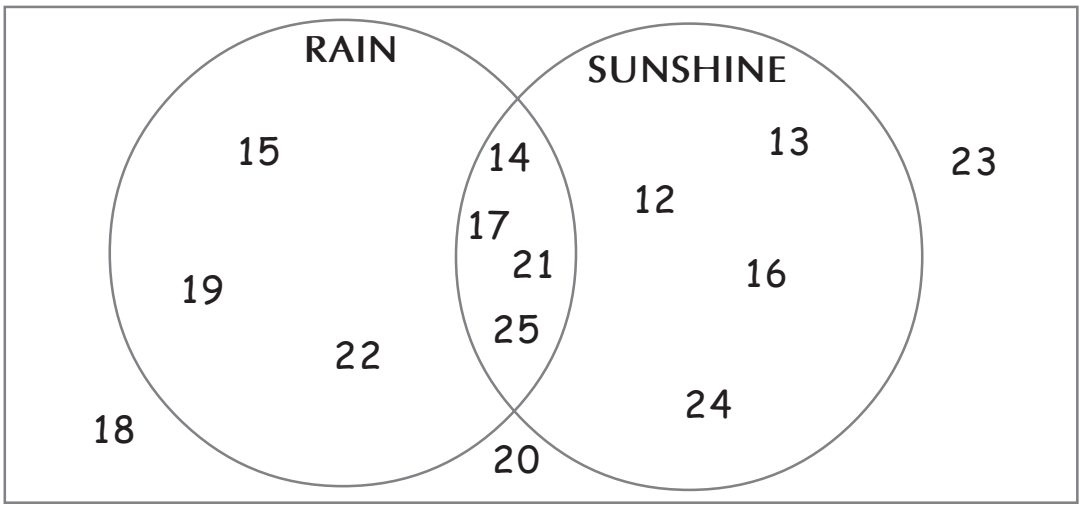


Cut out the boxes for each date.



c. Take the date boxes that have **rain** and sort them into two piles: **dates with rain but no sunshine** and **dates with both rain and sunshine.**
Now think! Where will you write these dates in the following diagram?

d. Now take the date boxes that have **no rain** and sort them into two piles: **dates with sunshine and no rain,** and **dates without sunshine or rain.**
Put all these dates in the correct parts of this diagram.



This is the first introduction of students to 'Venn Diagrams' – more examples are given in Chapters 3 and 8. Working with the mathematical notion of 'Sets' requires analysis and abstract thinking which may be beyond the current capability of most students. Therefore in this task, the abstract analysis is guided by a series of concrete steps involving cutting and pasting/ or sorting. With some help from the teacher the task should be accessible to students of Class 4. In the beginning if students find it difficult to handle a large number of dates at once, the activity might be done for just one week of the calendar. The correct categorisation of the days is shown in the diagrams here.

Show and tell (WB p. 31)

1. Bring something that you can find only during a particular season or time of year. Show it to the class and tell them about it.

Students might bring a flower, fruit or vegetable that is only found (perhaps in a raw or a ripe form) during a particular time of the year. Other imaginative responses are possible.

Ask a question (WB p. 31)

1. Ask questions about the weather. Think of how you will try to find the answers.

Student's question:

Why do the rains come at the same time every year?

I suggested students could look for the explanation in some Geography textbooks. A rough map of India drawn on the board would also help. In the hot summer a lot of water evaporates from the Indian Ocean and forms clouds. In the meanwhile the land over Central India and China becomes very hot and the air there rises up. The other vast mass of air from the ocean, carrying clouds with it, rushes to take its place.

DID YOU KNOW? (TB p. 14)

In October and November every year cyclones form over the Bay of Bengal. A cyclone is a huge rotating storm. It could be hundreds of kilometres wide. Cyclonic winds blow very fast - up to 300 kilometres per hour (three times as fast as an express train). They make huge waves and blow sea water far into the land, causing floods, uprooting trees, destroying houses and killing tens of thousands of people.

We discussed in the classroom a recent severe cyclone in Orissa which students had heard about and watched on the TV news.

CHAPTER 2

Day sky, night sky

ACTIVITIES

Watching the sky

1. Here comes the sun! (3 periods; TB p. 15)

a. Watch the sunrise and sunset. In which direction did the sun rise? In which direction did it set? (WorkBook pages 36-37)

Students' responses

I asked the students about their times of waking up and going to bed, and thus how many of them were able to watch the sunrise and sunset. Some students in a city school said that they had never seen the sun rise. Students in a residential school had all seen the sun rise from behind a particular tree in their compound. They had noticed that the rising and setting sun looked redder, larger and less bright than when it was high in the sky.

The direction of sunset - behind the school building - had been discussed during the activity on wind direction and while drawing the sky, but this idea was still not clear to everyone. Probably these concepts need more time to develop. It would help to make frequent reference to directions while talking about the sky and about locations of places.

b. Find out the time of sunrise and sunset every day for at least one week. You might find these times from a newspaper, an almanac, an older person, or by watching for yourself. Do this for one week in summer and one week in winter.

Did the sun rise at the same time every day? Did it set at the same time every day?

What can you say about the times of sunrise and sunset in summer and winter?

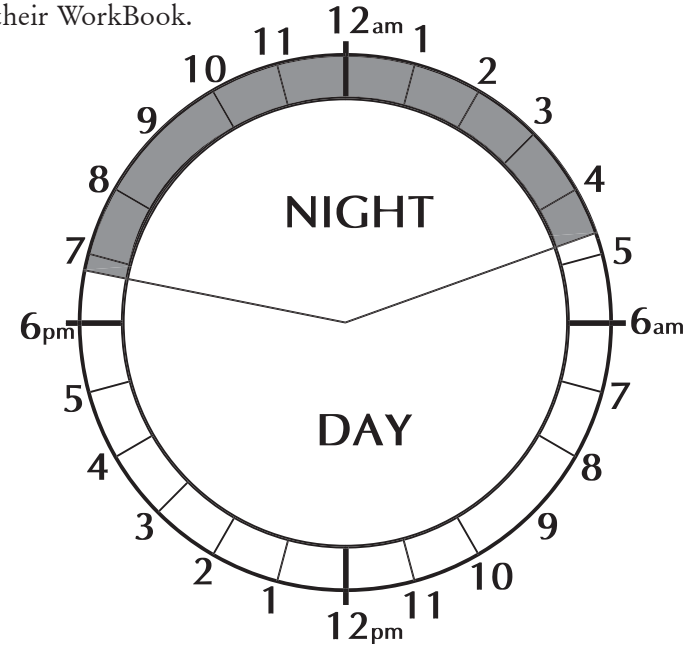
In the circle in your WorkBook (p. 37) shade the night time between **sunset** and **sunrise** for one day in summer and one day in winter.

What can you say about the length of the days in summer and winter?

Students' responses

Of the students who regularly watched the sunrise, the majority had noticed that the place of sunrise gradually moved (northwards) as the year progressed. During the winter the sun set behind the tamarind tree, while during summer it set behind a building towards the north. I was surprised and pleased at these close observations which they had made much before being taught these things in school!

I drew a diagram on the board to show that the length of the day and the night are determined by the times of sunrise and sunset. This helped them do the shading in the first ring on page 35 in their WorkBook.



Classroom experience

Students also had to observe that the days are long in summer and short in winter. Even during one week of measurement the decrease in the length of day was seen. The summer data was collected while doing this Unit while the winter data was collected later in the year. Alternatively the data below could be used. The reasons for the variation in daylight hours are complex (but see *Student's question* on page 77).

The times of sunrise and sunset in Mumbai for a week in June and a week in December are given below. In the more Northern latitudes one would find more variation from day to day and a larger difference between the length of days in summer and winter. The extremes are at the poles where it is six months of day and six months of night. Towards the equator, the difference between summer and winter becomes less. At the equator the days and night are twelve hours each throughout the year.

Place: Mumbai

Day	Time of sunrise	Time of sunset
Tue. 1 Dec. 1998	06:56	18:00
Wed. 2 Dec. 1998	06:56	18:00
Thu. 3 Dec. 1998	06:57	18:00
Fri. 4 Dec. 1998	06:57	18:00
Sat. 5 Dec. 1998	06:58	18:00
Sun. 6 Dec. 1998	06:59	18:01
Mon. 7 Dec. 1998	06:59	18:01
Wed. 1 Jun. 1999	06:01	19:12
Thu. 2 Jun. 1999	06:01	19:13
Fri. 3 Jun. 1999	06:01	19:13
Sat. 4 Jun. 1999	06:01	19:13
Sun. 5 Jun. 1999	06:01	19:14
Mon. 6 Jun. 1999	06:01	19:14
Tue. 7 Jun. 1999	06:01	19:14

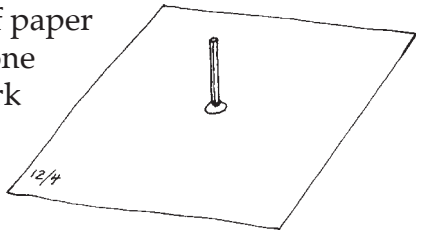
2. Shadow play (3 periods + home-work; TB p. 15)

a. Stand in a sunny, level place in the morning. Ask your friend to measure the length of your shadow. Do the same around noon and in the late afternoon.

Activities 2a.-2c. were done outdoors by the students in pairs.

Some used their rulers to measure the length of the shadow while others measured it in strides or steps. They realised that to compare lengths the step unit had to be the same for each measurement.

b. Stand a matchstick at the centre of a sheet of paper using thick glue or dough. Write the date on one corner of the paper and keep it in the sun. Mark the shadow of the matchstick at several times during the day. Write the time next to each shadow (WorkBook pages 38-39).

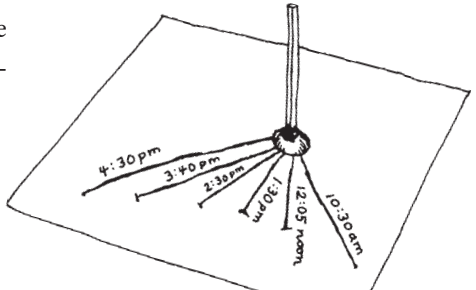


When did your matchstick give the longest shadow? When did it give the shortest shadow?

Was your match shadow ever the same length as your matchstick? If not, guess when it would be the same length.

Did the other students' matchsticks give the same length shadows as yours? If not, why not?

Some had trouble making the matchstick stand at the centre of the paper, but thick glue helped. Some matchstick shadows marked by students are shown here.



c. Play this game with sunlight or some other bright source of light. Make shadows on a wall or the ground. Now ask a friend to stand behind you and make shadows using different things. Guess what the thing is by looking at the shadow.

The sunlight shadows were done in school. I asked students to observe more shadows with artificial lights during the night.

3. Moon watch (Observations at home + 2 periods classroom discussion)

a. Watch the moon. Does the moon also rise and set? In which direction did the moon rise? In which direction did it set? (TB p. 16)

b. Watch for the moon every night. Draw its shape in the calendar on page 40 in your WorkBook.

crescent moon **half moon** **gibbous moon** **full moon**

On which dates did you see a crescent moon?

On which dates did you see a half moon?

On which dates did you see a gibbous moon?

On which dates did you see a full moon?

Did you ever see the moon during daytime? What was its shape then?

On which dates did you not see the moon at all? Why?

Students' responses

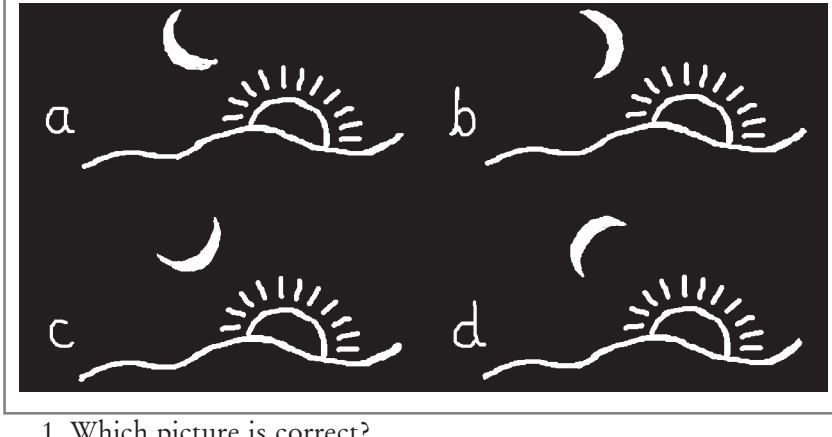
I found during the discussion that some students did not know about the rising and setting of the moon. Others imagined (wrongly!) that the moon comes up when the sun

goes down, or that it is always in the sky at night but never in the daytime. The later days of observations, done by students on their own, clarified these ideas.

I was surprised when one of the students remarked, "The nights are cool because of the moon!" Another student added, "The sun gives us warm light but the moon gives us cool light!" I asked others whether they agreed - many did not. One of them argued that nights are cool even when there is no moon in the sky. I told the students that the sun is very hot, it gives out light and heat. The moon shines because it is lighted by the sun. I asked them to observe that the lighted side of the moon is always turned towards the sun.

BLACKBOARD WORK

To reinforce this idea I drew pictures of the crescent moon near the horizon on the blackboard as below. This discussion helped students to do the *Figure it out* questions on pages 75-76.



1. Which picture is correct?
2. Is the sun rising or setting?
3. Is the moon about to set or did it just rise?
4. In which direction would you look to see such a picture?

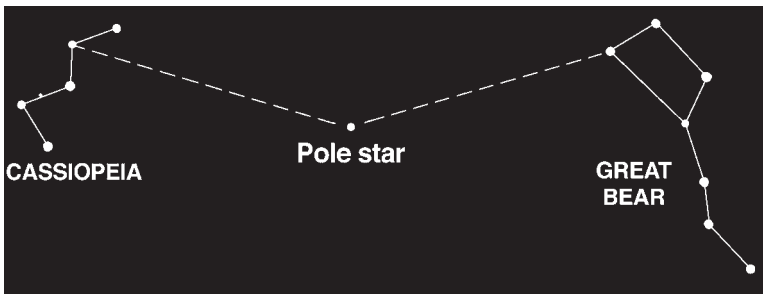
Students' responses

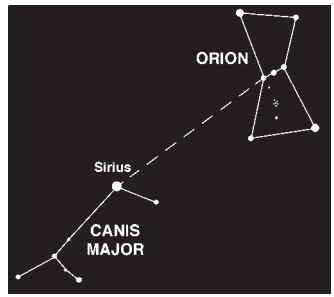
Students knew of many festivals associated with the moon. They found out more from their parents (see Exercise *Name and draw*). They had their own names for shapes of the different phases of the moon: like a garlic clove (for Bakri-Id), growing into a banana, then a boat, a watermelon, a filled bowl and finally a ball!

4. Starry night (Observations at home + 4 periods; TB p. 16, WB p. 41)

a. You can recognise stars from the patterns they make in the sky. These patterns of stars are called **constellations**. Look for the constellations Orion (*Mruga*), Cassiopeia (*Sharmishtha*), and the Great Bear (*Saptarishi*) in the pictures on page 17 in the TextBook.

b. Look for constellations in the sky. Find the same constellation again after one hour (WorkBook page 41).





c. Find these stars in the night sky: the Pole Star (*Dhruv Tara*) and Sirius (*Vyadh*). You see the Pole Star (*Dhruv Tara*) in the northern sky. It is the only star that never seems to move. Use Cassiopeia and the Great Bear as guides to find the Pole star.

Sirius (*Vyadh*) is part of the constellation Canis Major. Use Orion to find Sirius.

d. Planets look like stars but they do not twinkle. Look for some planets in the sky.

Practical hints

Observation of the night sky is an activity that, with little practice, can provide years of enjoyment to everyone. Usually this activity is not done in school, simply because the observations have to be done at night. However, some introduction in school, along with observations by students at home, could make a beginning. Possibly at least one night of observation might be arranged for the whole class.

Stars are best visible in a moonless part of the night. Around the middle of the waning phase of the moon (*krishnapaksha*) the moon rises late so observations can be done at a convenient time, e.g. 8 pm to 10 pm. City lights and air pollution are big hindrance to star watching; and if you are going from a brightly-lit area out into the night, for best vision you should allow 20-30 minutes for your eyes to get adapted to the dark.

Locating a star or constellation in the sky with the help of a star chart is not an easy task. It takes some time for a novice to realise that the small star-patterns drawn in the book in fact cover large areas of the sky. In unpolluted rural areas the visibility might be so good that many more stars are visible than are shown in the pictures, while in cities, fewer stars would be visible. In both cases it becomes difficult to match the patterns in the sky with those shown in the book. The first few constellations should really be pointed out by someone who is familiar with them. Therefore only some popularly known constellations are shown in the TextBook - the exercises are more like puzzles in which students search for shapes and get practice in recognising these few constellations.

> Constellations, or groups of stars that appear to be close together, were noticed and named by early human beings. The stars visible to us are the ones closest to us in our own galaxy, which is shaped like a huge flat spiral about 100,000 light years across and containing about 100,000 million stars. On a clear night several thousands of these stars are visible to the naked eye. Close to a city with its bright lights only a few hundreds or even less might be visible.
>
> Watching the stars in the course of an hour will help the students see that stars too move across the sky. Like the moon and the sun, they rise and set because of the rotation of the earth. In the course of the year, due to the

earth's revolution around the sun, the stars appear to advance across the sky and new stars become visible in the night sky. If you look at the stars at 9 pm. on one day and then again at 11 pm., all the stars would have moved to the West. Some more stars would have risen in the East and those which were close to the Western horizon would have set. Actually you will see the same star positions that you would see one month later at 9 pm. For observations therefore it is necessary to know during which months a particular constellation is visible in the night sky during a convenient time period.

Constellation	Visible from 8-10 pm in the months
Orion	December to April
Cassiopeia	September to February
The Great Bear	February to July
Canis Major	January to April
Gemini	December to May

The pictures of the Northern and Southern sky on page 17 of the TextBook are drawn for latitude 20°N. The sky will look slightly different from other latitudes - as you go North, the pole star and the northern constellations will be a little higher in the sky while Orion and Sirius in the South will be closer to the horizon. In Southern India the northern stars will be lower and the southern ones higher.

Think Think!

A lighted lamp looks brighter at night than it does during the day. Mini said, "Lamps give more light in the night". What do you think?

Apu thinks that there are stars in the sky even during daytime, but you cannot see them. What do you think?

A similar thing happens when there is a lighted candle in a dark room and you put on the electric light. The candle continues to give the same amount of light but in comparison to the electric light it appears dimmer to us.

Know these words

crescent moon	constellation
gibbous moon	star
full moon	planet

EXERCISES (6 periods + homework)

Observation-based exercises

Name and draw (WB p. 42)

1. Draw the shape of the moon on some festival days, for example: Buddha Purnima, Dussera (Vijaya Dashmi), Bakri Id, Guru Parb (Guru Nanak Jayanti), Diwali.

(See phases in *Ask and find out*, page 74)

What's the same? What's different? (WB p. 42)

1 Give two similarities and two differences between:

a. The sun and the moon

b. A stick and its shadow

c. The moon when it is rising and when it is high in the sky

d. Sunrise and sunset

The rising or setting moon often looks reddish or yellowish, and it appears bigger than the moon high in the sky. Many responses are possible for the others.

Talk and write (WB p. 43)

1. Remember some poems or songs about the moon, sun or stars. Make up some new ones.

Students remembered many poems and songs. Most were based on pure fantasy, unlike the poems recalled earlier on the seasons which combined romance with descriptions of nature.

Ask and find out (WB p. 44)

1. In the **Name and draw** exercise you have drawn the shape of the moon on some festival days. Find out about other special days that are celebrated on particular days of the moon.

Since most Hindu, Muslim, Buddhist and Jain festivals follow the lunar calendar, the shape of the moon on many Indian festival days is predictable. Makar Sankranthi is celebrated on January 14th, when the sun is at a particular point in its orbit (near the constellation of 'makar'). It is probably the only Hindu festival celebrated by the solar calendar. Of Christian festivals, Christmas is clearly celebrated by the solar calendar. Easter, being the first Sunday after the first full moon after the Spring equinox (March 21) is thus fixed by a combination of the solar calendar and lunar phases. Many other Christian festivals follow a fixed period after Easter. Jewish festivals too similarly depend on both the solar and lunar calendars.

Shape of the moon on a few festival days:

Amavasya (New moon): Mahashivratri, Diwali (Laxmi Pooja), Pola

Beej/ Dooj (second day after the new moon): Ramzan Id, Bhai dooj

Chaturthi (fourth day after the new moon): Ganesh Chaturthi

Panchami (fifth day after the new moon): Basant Panchami, Nag Panchami

Dashmi (tenth day after the new moon): Mohurrum, Bakri-Id, Dussera (Vijaya Dashmi)

Twelfth day after the new moon: Id-e-Milad

Poornima (Full moon): Holi Poornima, Mahavir Jayanti, Hanuman Jayanti, Buddha Poornima, Guru Nanak Jayanti, Guru Poornima, Raksha Bandhan, Kojagiri Poornima, Datta Jayanti

Chaturthi/ Chauth (fourth day after the full moon): Karva Chauth

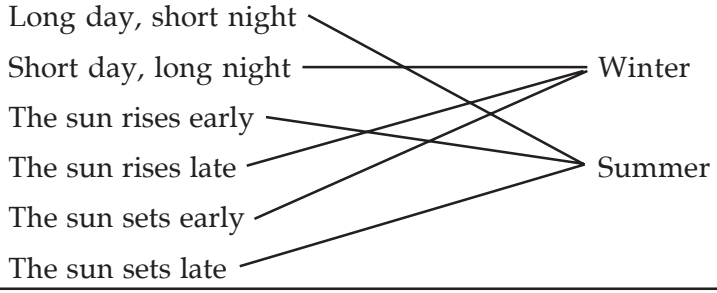
Ashtami (eighth day after the full moon): Gokulashtami (Gopal Kala)

2. Find out some stories about the constellations.

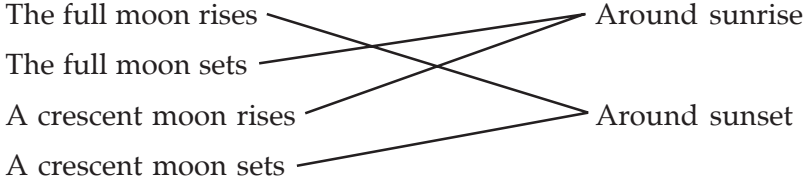
Many stories in the ancient Indian as well as Greek traditions, could be told. Some good reference books are cited on page 342.

Figure it out (WB p. 44)

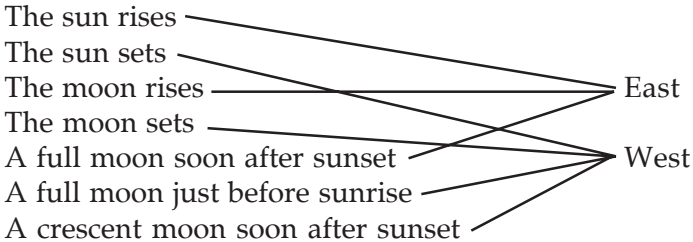
1. Match the happenings on the left with the two seasons on the right:



2. Match the events on the left with the times on the right:



3. Match the events on the left with the two directions on the right:



4. Follow the instructions in your WorkBook to draw stars on the graph. Look at the sky pictures on page 18 to find which constellation you have made.

The Great Bear or the Big Dipper (*Saptarishi*) and Orion (*Mruga*)

5. Look at the pictures in the WorkBook and guess what time it is in each picture.

The first picture obviously shows a scene around mid-day (1:07 pm) while the second could be morning (7:00 am) or evening (4:55 pm).

Ask a question (WB p. 46)

1. Ask questions about day and night. Think of how you will try to find the answers.

Students' question:

Why are the days longer in summer than in winter?

This is a natural question after the observations on length of day in summer and winter. The full explanation would involve the tilt of the earth's rotational axis with respect to its orbit around the sun - a difficult 3-D visualisation for students of Class 4. However through some simple everyday observations we might get them to think further: like, in summer the sun goes up higher in the sky than it does in winter. We sometimes describe this by saying, "the sun is hotter in summer." The height (elevation) of the sun above the horizon is measured by the length of shadows. Activities 2a. and 2b., if done in both summer and winter, would show that all (at any given time of the day) the winter shadows are longer. (But note - in the tropics the shortest shadow would occur not on the longest day but on the day that the sun is above that particular latitude.) Through such observations students might notice that in winter the sun moves along a shorter arc in the sky (which is towards the South). It is therefore up in the sky for a shorter time than in summer.

DID YOU KNOW? (TB p. 20)

The earth is shaped like a big round ball. We live on this ball.

The moon is a ball that is smaller than the earth.

Our sun is a very big and very hot ball of gas. It is many times larger than the earth.

Stars too are hot balls like our sun but they are much, much further away from us. Many stars are bigger and brighter than our sun.

If the earth were this big ◯

this is how big the moon would be ∘

and then the sun would be so big it would not even fit on this page.

SUPPLEMENTARY EXERCISES

1. Write down whether these times of the day are usually 'warm' or 'cool'.
   Early morning .....
   Afternoon .....
   Late evening .....
   Night .....

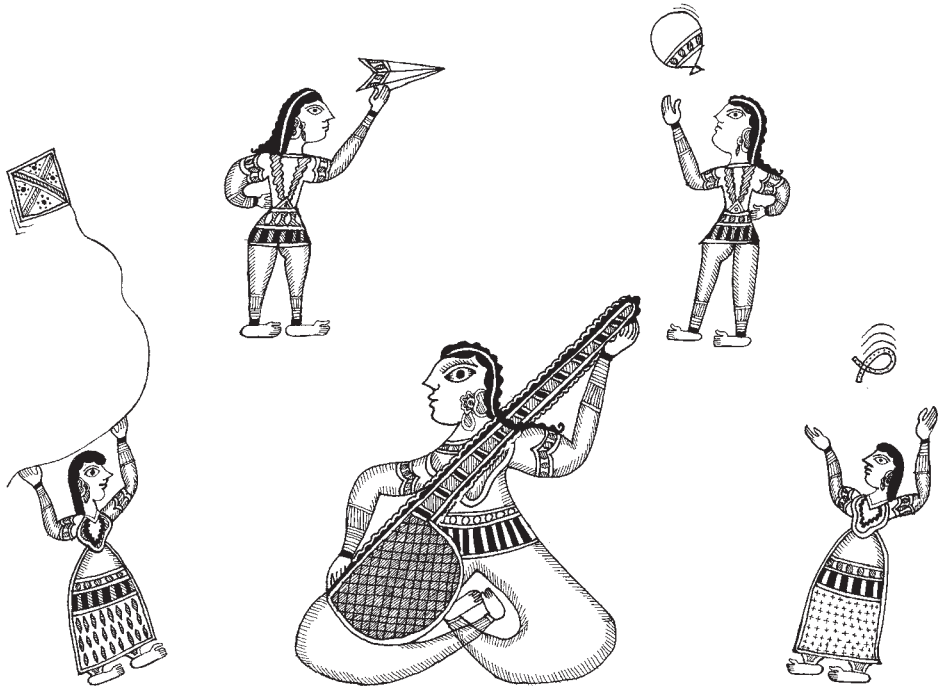
2. Mini is running in the rain. In which way should she hold the umbrella so that she does not get wet? (Assume the rain is falling straight down.)

a **b** **c** **d**

3. Ask about any old sayings relating to weather. For example sometimes the constellations seen in the night sky are related with the weather, or contain instructions for agricultural activity. Are these old sayings true or useful?

4. Write the following from the one nearest to you to the one farthest from you:
   moon, sun, stars, clouds, a flying crow

a flying crow (100 m), clouds (1-10 km), moon (384,400 km), sun (150 million km), stars (the nearest star is alpha centauri, about 4 light years away)



UNIT 2

AIR

Chapter 3 Fun with air!

Chapter 4 What's in the air?

UNIT 3 Fun with air!

AN OVERVIEW

Objective **To experience varied phenomena related with air and to understand the importance of clean air for life.**

2.1 To realise that air is a material substance present all around us: though it cannot be seen it can be observed in other ways

2.2 To explore everyday phenomena related with air pressure and movement: air can be squeezed, it can flow up or down, it can move, push, carry, and lift things, it can make things move in unexpected ways

2.3 To observe how things move through air, exploring effects of weight, size, shape and thrust

2.4 To observe and experiment with air bubbles

2.5 To find out ways of making sounds with air, identify differences in pitch, loudness and quality of musical sounds, to recognise and classify musical instruments into three major groups, to design and make a simple musical instrument

2.6 To know that air is a mixture of gases and to know the names of some of these gases: nitrogen, oxygen, carbon dioxide and water vapour

2.7 To realise that air is essential for life (and therefore for us) - that we need to breathe air continuously

2.8 To know that plants are necessary to sustain enough oxygen in the air

2.9 To realise that air carries smells, dust and other tiny things

2.10 To know the existence of tiny living things (microbes) which are all around us

2.11 To understand ways in which air gets polluted and to realise that clean air is essential for good health

What is new in this Unit

The traditional curriculum begins with the topic of 'matter', which is classified into solid, liquid and gas. In *Small Science*, rather than starting with the abstract concept of 'matter', we explore common 'materials'. We believe this approach is appropriate for primary school. The idea of solid, liquid and later, gas, is understood intuitively; introducing their formal definitions too early often only serves to confuse students.

Some materials and their properties occurred in Class 3 in the Unit 'Making Houses'. Air and water are materials too: here gases and liquids are introduced through the Units on air and water. More everyday materials like fabrics, will be explored in Class 5.

Seemingly simple concepts related to air are in reality quite subtle and complex. For example, young children think of air as 'emptiness' or 'nothing'. To understand that 'air occupies space' or that 'air pushes things', one needs to conceive of air as matter. To know **what** it is that occupies space, requires the notion of atomicity which is here introduced in a simple way through the drawings.

When the idea that 'air is a material substance' is so problematic, it is even more difficult to grasp that 'air is made of gases', and further, that it carries dust, microbes etc.. These extremely subtle notions are introduced in Chapter 4 through a variety of organised experiences, observations and graphics. Detailed explanations are not given - though enough information is provided for the teacher who may choose to go beyond this minimal exposure. These simple but organised experiences in childhood should start a process of thinking that will crystallise into clear concepts only much later.

The second major theme in Chapter 4 is clean and polluted air and the importance of clean air for life. Health and environmental issues are integrated into this chapter.

Time-table P: Number of periods

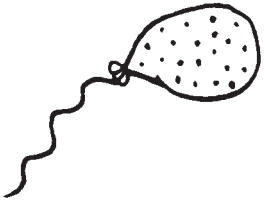
Chapter 3		**Chapter 4**	
P1	- Story	P27	- Story
P2-P21	- Activities and discussion	P28-P39	- Activities
P22-P26	- Exercises	P40-P44	- Exercises

Some exercises to be done along with activities and as homework.

Materials and information to be collected for the Unit

Chapter 3: Paper or plastic bags, three glasses, bicycle pump or pichkari, a large newspaper sheets or cardboard; seeds of different shapes, glue; scissors, drinking straw, bowl, soap /washing powder / shampoo; 8 identical empty bottles, balloons, rubber bands, any musical instruments.

Chapter 4: Balloons, full soda water bottle; broom, pieces of cardboard, white cotton cloth or paper, string or clips, vaseline, hand lens.



CHAPTER 3 **Fun with air!**

STORY (1 period; TB p. 23)

Airy story

Mini came quietly into the room. She looked as if she was hiding something. Her mouth was full.

"What are you eating?" demanded Apu. "I want it too!"

Mini took Apu's hands and smacked his palms against her cheeks.

"Phrroop!" came the funny sound.

"It was nothing!" said Apu, disappointed.

"Yes, it was something!" Mini laughed. "It was air!"

"Air!" exclaimed Apu.

It's everywhere,
It's all around,
In corners, cracks,
And under the ground.

It bubbles, it blows,
It creeps and it flows,
It whistles, it sings,
Lifts birds on their wings.

Run, and you will feel it!
But never will you see it,
It looks like nothing, but it's there,
Rushing, pushing everywhere!

Classroom experience

Students liked the story and the poem. They also enjoyed imitating Mini's action. "Where was this air before it came into Mini's mouth?" They replied that it may have come from outside or from inside her - when she puffed out her cheeks she made room for air. Could they guess what Mini was thinking as she entered the room? Only one student responded (correctly) that she wanted to fool Apu, to make him think that she was eating something. Others said she wanted surprise Apu or that she just wanted to make the funny noise. I realised that though the main point of the story was clear to students, more subtle aspects like intentions and expectations were not immediately understood.

New words in the story

(Many of these words they had learnt before, but forgotten.)

demanded, palm, whistle, exclaimed, hiding, quietly

ACTIVITIES

Air all around!

1. Air inside everything (2 double periods, including discussion of related exercise questions; TB p. 24, WB p. 49)

a. Take a paper or plastic bag. Open it. Check to be sure it is empty. Squeeze and press on it. You can easily flatten it.

Open the bag again. This time close the mouth of the bag tightly. Now is it easy to squeeze the bag?

What is inside the bag?

b. Hit the bag against the palm of your other hand. *Phutt!*

Describe what happened. (WorkBook page 49)

Classroom experience

In the previous week I had asked students to start collecting a variety of used bags, made of newspaper, brown paper, polythene, even used postal envelopes. Minor problems occurred while doing the activity. If the mouth of the bag was not held tight, the air did not stay inside (plastic bags with mouth twisted and closed worked better than paper ones). Some bags had holes, which was fortuitous because students realised that air escaped through the holes. Finally they enjoyed making the 'phutt' sound.

I further dramatised the situation by keeping a thin plastic bag with some rice in it along with a similar 'empty' one with air blown inside and its mouth tied tightly. Though one was much lighter than the other, you could press both and feel something inside. The experience of pressing the closed bag made students realise that there was some'thing' inside the bag.

There was an interesting discussion here on 'air is everywhere' (see *Classroom discussion* 1 and 2 , pages 114-115).

c. Take three glasses. Keep one of them upright. Keep the second glass on its side. Hold the third glass upside down. *Think* about what happens to the air inside these three glasses. Make your own guesses.

Is there air in all three glasses? Does the air inside the glasses stay inside them always? Does it come out of the glasses? Does air from the outside get in?

Students' alternative conceptions

After the discussion on 'air is everywhere', most of the students agreed that there was air even in an upside-down glass. But many thought that the air in an upright glass would stay inside while that in an upside-down glass would flow out of it!

Finally, most students guessed (correctly) that air in all the glasses would be coming in and out all the time as it was free to move.

This movement is called 'diffusion'. Air molecules, which move in random directions at around 1800 km/hr (see page 94), eventually move out of the open glass whichever way it is oriented. It is not a 'wind': there is no flow in any particular direction.

Think! Think!

It is easy to squeeze the bag when its mouth is open, but difficult when its mouth is closed. Why?

Students' observations

With the mouth of the bag closed, the air (or rice) inside was trapped. If the mouth of the rice bag was opened, it could be squeezed, making some of the rice spill out. The students could think of something similar happening with air.

What made the "phutt" sound? Did the bag tear? Why or why not? Name some other ways of making sudden sounds.

We discussed the 'phutt' sound after doing Activity 6 (Air makes sound). Students interpreted 'sudden' as 'quick', 'loud' and 'unexpected'. In sounds like the bursting of a paper

bag, which last for a very short time, air escapes suddenly. These sounds are the result of a 'shock wave'. Students' examples: bursting a balloon, tyre, light bulb, fire-crackers, a home hot-water geyser, breaking glass, various sharp sounds of beating and hitting, falling and clapping.

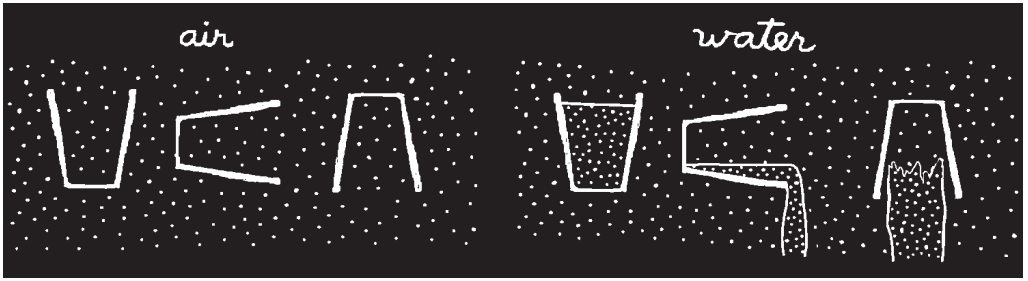
I asked, "How should we clap to make the sound louder?" Students found that clapping the palms together makes a louder sound than clapping fingers together. If you cup the two palms together, more air is trapped between the palms, making an even louder sound. I also demonstrated that when air escapes suddenly it makes a bang, but if it escapes gradually (as from the stretched mouth of a balloon) it makes a long whistling sound.

On why the bag tore, students explained in various ways that the air had to find a way to come out. I asked, why did the air come out of one particular place in the bag rather than any other? Then they observed the torn bags closely. Some noticed that all the bags had torn along the folds or in the thinner and weaker portions. Air had found the easiest place from which to escape. Incidentally students noticed that folding breaks some of the fibres that constitute the paper.

> *Suppose the three glasses were filled with water instead of air. From which of the glasses would the water flow out? Is there a difference between the way water flows and the way air flows?*

Water would flow out of only glasses 2 and 3. The water inside glass 1 could not come out except by evaporation, that is, by turning into a gas. I drew some pictures on the blackboard to show air and water in the glasses.

BLACKBOARD WORK

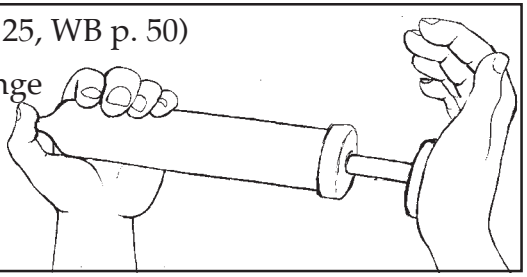


Glasses containing air. **Glasses containing water.**

The dots represent molecules of air or water. All the molecules are constantly moving. The air molecules are moving in and out of the glasses, even when you can't feel any air movement. The water molecules are moving in the water, from the water to the air and from the air to the water.

2. You can squeeze air (1 period; TB p. 25, WB p. 50)

Take a bicycle pump, pichkari, or a syringe without the needle. Close its mouth tight and push the piston in hard. Then let go of the piston. Describe what happened on page 50 in your WorkBook.



Classroom experience

Before doing the activity I asked students to predict what would happen (i.e. would the piston move?). About one-third said that the piston would go in all the way; another third said it would go part of the way; the rest said it would not move at all. They were surprised by the results, which I compared later to pressing a rubber or sponge, and to children moving in a room and after they are confined to a smaller space.

Practical hints

It is important that the pump is not leaky and that its mouth is closed very tight. Since most students were not able to hold so tight, the activity was successful only when I

demonstrated it. I had to press very hard to drive the piston in by a few centimetres. (Since the motion of the piston was very small, I had to repeatedly draw the students' attention to it.) On releasing, the piston came back to its original position. This will not happen if any air is allowed to escape. One of the students put it well, "The piston moved in because the air got all piled up inside." *Classroom discussion* 3. was done here.

We also tried to squeeze the air inside a balloon but this did not work well: the air appeared to just move from one side to another. If the balloon was partially full it stretched to make space for the air; if it was too full it simply burst. In comparison with the walls of a syringe or pump, the material of the balloon was not strong enough to withstand the increase in pressure when the air was compressed.

Think! Think!

We fill air inside balloons, footballs, cycle tyres and many other things. What would happen if we filled these things with something else? Imagine what would happen if they were filled with water, or sand, or crumpled paper . . .?

If balloons, footballs, tyres and inflatable toys were filled with water, or something else, they would become too heavy, and therefore difficult to move, throw, etc.. You might injure your toe by kicking a football filled with sand. Discussion of such experiences now would help students later in developing concepts of mass and of action/ reaction.

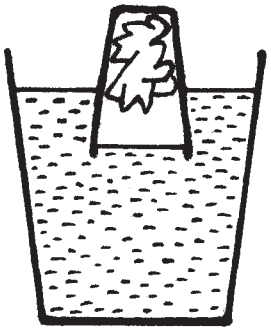
Air is light and it is also elastic. 'Elastic ' means that if it is pressed and released it springs back to its original form. A football bounces because it is filled with air which is elastic. If filled with water, sand or paper, it would not bounce. Steel is heavy, but elastic. A ball made from steel would be difficult to throw, but it would bounce very well.

Additional activity

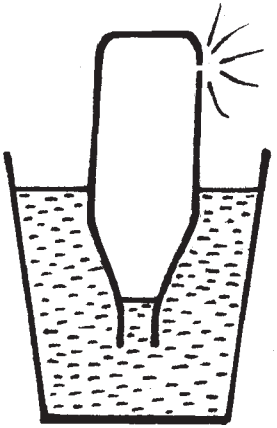
If students appear comfortable with the idea that air is matter, then more careful experiments and discussion could be done. For example, you could do an experiment to show that:

(a) there is something inside an inverted 'empty' glass
(b) when squeezed it can occupy a smaller space
(c) if there is a way out, it can escape; you can sense that it is air that is escaping.

Inverted glass with crumpled paper in water



Air hissing out of hole in plastic bottle



Experiment and interpretation

Try to push an inverted glass into a bucket of water without tilting it. This is difficult to do. Now stuff a piece of crumpled paper or handkerchief into the bottom of the glass before pushing it deep into the water. You find that the paper or cloth remains dry. Something stopped the water from filling the glass. But you can see that the glass is wet up to a few millimetres inside the rim. Perhaps the water entered the glass till a certain point - the 'thing' inside might have got squeezed into a slightly smaller space.

One might also speculate that some of the contents of the glass could have dissolved in water. Such alternative interpretations are always possible. The fun in science is to find out - by experiment and argument - which interpretation is most likely. And then to be prepared to be proven wrong!

Practical hints

Different shapes of containers could be tried. In a tilted wide-mouthed glass, water enters easily. With a narrow-mouthed container, you get bubbles as the water enters. If you use a thin plastic or thermocol cup (used to serve tea at railway stations), then you can make a small hole at the bottom with a pin. The water easily enters the cup and wets it. With a larger container like a plastic bottle with a pin-hole, you can feel and hear the air blowing out - it makes a hissing sound.

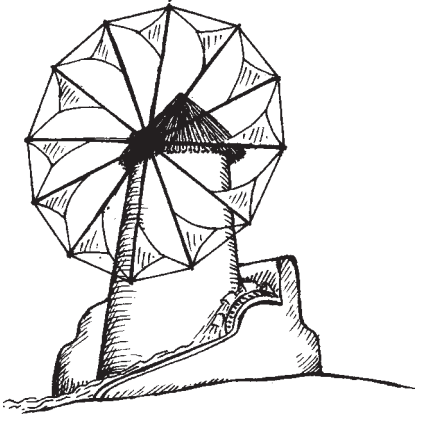
3. Air moves and pushes things (Double period for outdoor activities - can be combined with PT period - followed by 2 periods for discussion)

a. Moving air is called wind. List some things that you have seen moving with the wind. (WorkBook page 50)

Classroom experience

Students gave examples of, clothes on a line, leaves, flag in the wind, kite and sailboat. Many of these had come up in Chapter 1 discussions.

The picture in the TextBook shows a modern windmill which is used to produce electricity. Harnessing wind power does not degrade the environment like thermal and large-scale hydroelectric power does. Using the wind as a source of energy is a relatively recent development in India. As yet, of India's wind energy potential estimated at 20,000 MW, only about 1000 MW is tapped.



English-medium students in India sometimes know of 'windmill' and 'miller' from children's stories originating in Europe. Windmills were used for several centuries in Europe, particularly in Greece, Belgium and Holland. They have huge wheels with cloth sails as high as a two-storey building. The shaft of wind and water mills could be attached to various devices - a grindstone to grind wheat and corn, pump to lift water from

wells, bellows to forge iron, saw to cut wood and later even for spinning, weaving and threshing.

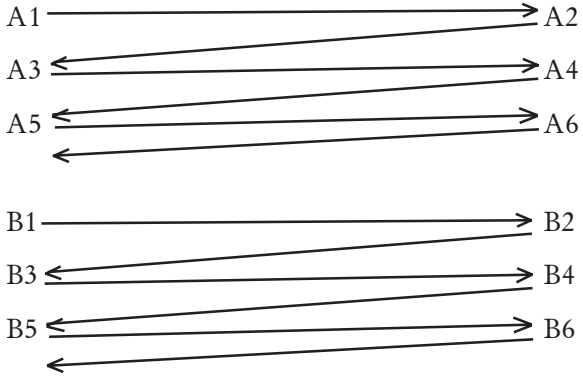
Traditionally in India water mills (turned by flowing water) were more common than windmills. One possible reason that mills did not come into common use in India might be that the prevailing notions of ritual purity led families to grind their grain at home.

Activities 3b. and 4d. were done in co-ordination with the PT teacher. 3b. was done as a relay race. Rules for the relay race were explained before the students went outdoors for the PT class.

b. Hold a large open newspaper or a sheet of cardboard. Now run. If there is a wind blowing, run with the wind. Then run against the wind. Feel the difference.

Classroom experience

Newspaper relay race: A relay race is run with two teams, A and B. In one version of the race each team divides into two groups, e.g. (A1,A3,A5) and (A2,A4,A6). The first runner in group 1 of each team (A1 and B1) runs with a baton or stick and hands it to the first runner in group 2 of the team (A2 or B2). This runner runs back and hands the stick to the second runner in group 1 (A3 or B3), and so on. The sequence is shown in the picture.



Here instead of a baton or stick we used a double sheet of newspaper rolled up or folded in half (a single sheet tore too easily). A trial run was done so that students understood how to hold the paper, who ran first, who passed the paper to whom and what was the end point of the race. The activity added to the fun and team spirit in the class.

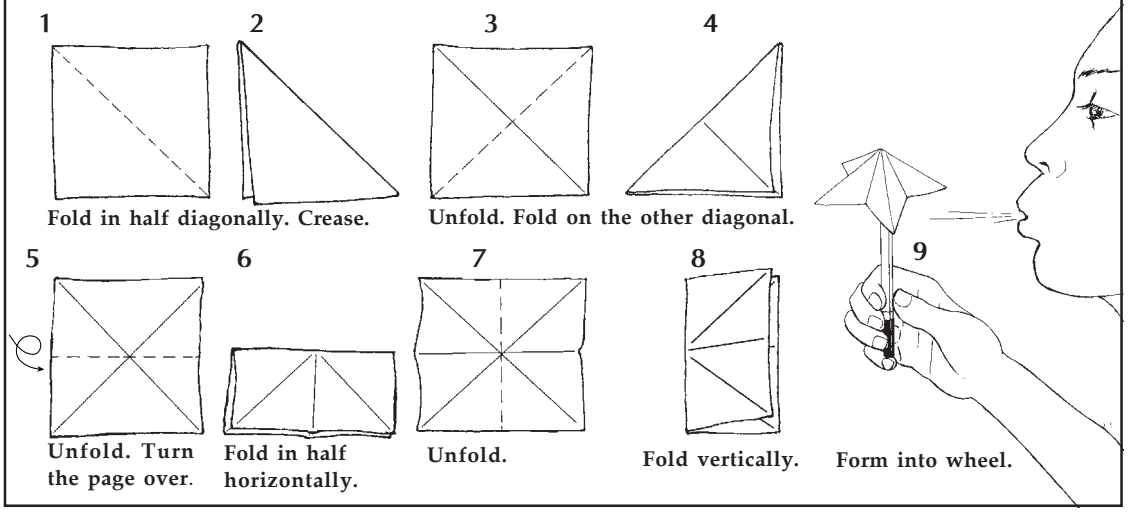
Students' observations

"It was a calm day;" "it was difficult to run with the open newspaper;" "the newspaper was pushing us back;" "it was like the sail of ship;" "the newspaper tore on the folded line."

Running with an open newspaper was compared with running with an open umbrella. Had there been a wind blowing in the right direction, it would have helped in the running.

One student wondered whether the sailboat or ship was always forced to move in the direction of the wind. (See *Students' questions*)

c. Make a **wind wheel**. Fold a 6 cm square piece of paper as shown. Put it on the point of a pencil and blow gently on one side. Describe what happens.



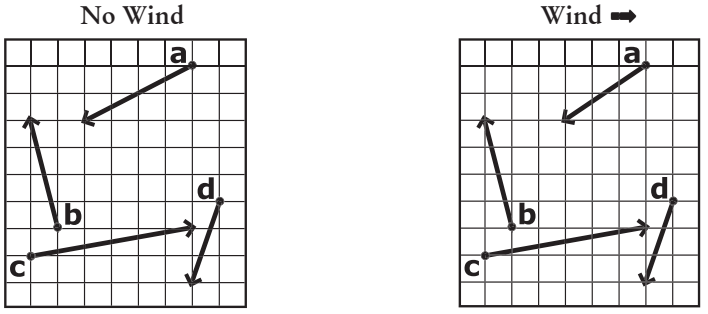
A simple activity that could be compared with the water wheel in Chapter 5.

Activities 1 and 2 have to do with air that is 'still', that is, there is no wind blowing. Even when we experience the air to be still, its molecules are actually moving very fast in different directions. The speed of air molecules is about 1800 km/hr at room temperature! In hotter air the molecules move even faster. In moving, they collide against the objects in their way; they collide against the walls of their container (for example the paper or plastic of the bag, or rubber fabric of a balloon). The result is that the bag feels full and the balloon stays stretched. We call this pushing the 'pressure of air'.
When you squeeze the balloon, the molecules of air get pushed closer together. Now there are more molecules bouncing off any given area of the balloon. Their push or 'pressure' is more. You can see that it makes the fabric of the balloon stretch. Paper and polythene are not able to stretch like this, so they tear.

Additional activity

Students could act out this concept in the following way. Lay a long rope in a big circle on the ground and pretend it is a balloon. Some students run about inside the circle and imagine that they are molecules of air. The students outside the balloon can move the rope, pretending to squeeze the balloon. The ones inside have to act out what happens - now they are forced to move in a different, perhaps smaller space. They can also act out what happens when the balloon breaks.

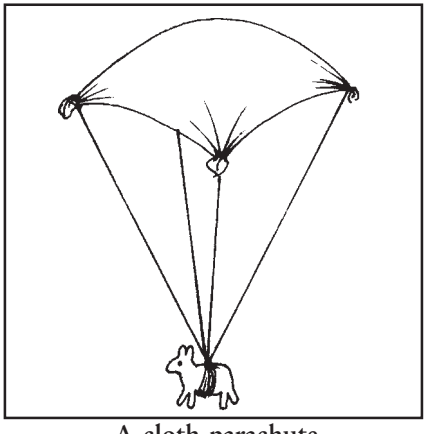
In Activity 3, the individual molecules are still moving very fast in random directions. But now the air mass also moves as a whole. This is a relatively much slower motion, or 'drift', in which all the molecules together move in one particular direction. This drift is called a wind (see the diagram).



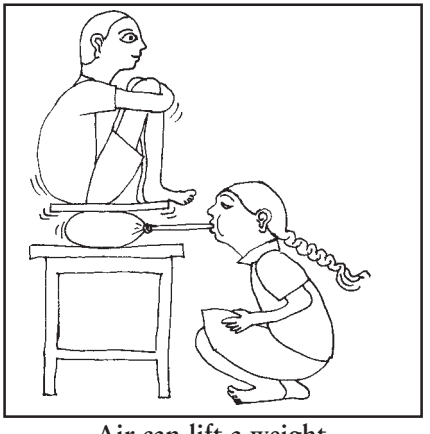
In the diagram on the left, the velocities of the four air molecules add up to zero, so the air is 'still'. But adding the velocities of the four air molecules on the right shows that the air is moving from left to right.

The wind in 3b is caused by **your** moving against the air. Whether you are still and the air moves against you, or whether the air is still and you move, the effect is the same: you feel a wind.

Some other simple activities involving air are illustrated below:



A cloth parachute



Air can lift a weight
(blow through a straw into a balloon)

4. Some shapes are carried easily by air (4 periods + homework; TB p. 27)

Why don't all objects fall straight down when you drop them? Gravity always pulls things down. If there was no air, an unsupported object would fall straight down. If you throw it forward, it would continue to move forward while falling down at the same time (i.e. it would follow a parabolic path downwards).

But an object moving through a fluid (for example, through air), meets with a force of resistance. Due to this resistance, very light objects (like droplets of water or ice in clouds, or the much smaller things illustrated in the TextBook on pages 40-41), fall down very slowly. So slowly that they are almost just suspended in the air and are carried along by the wind.

Objects might be just carried with the air, moving at the speed of the wind. But often they move **through** the air, that is, slower or faster than the wind. In that case, they experience another force, called 'lift'. Birds, insects and other animals move through the air by their own power; cars and airplanes move by the power of an engine; balls and toy airplanes are thrown by people; while leaves and seeds are carried by the wind. All these things are lifted, up or down, by the air moving past them.

To demonstrate the lifting force of air, take a strip of paper, hold it close to your mouth and blow over its top surface. The strip will fly upwards.

Besides being lifted, these objects moving through air are also slowed down by air resistance. The slowing-down force is called 'drag'. 'Drag' slows down the moving object, while 'lift' moves it up or down. Both lift and drag depend on the shape and orientation of the moving object. Shapes which experience a greater lift or a lower drag are the ones which move easily through air. They are called 'streamlined' shapes.

a. Collect seeds of many different shapes.

Look carefully at each seed. Do you think it can travel with the wind?

Put the seeds on your palm and try to blow them away.

What are the differences between the seeds that blow away easily and those that do not? (WorkBook pages 51-52)

Students' observations

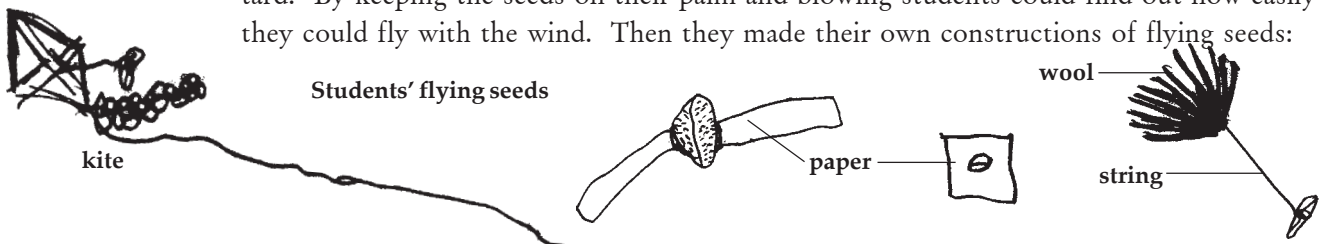
Students knew of some hairy seeds which they had played with, for example, marigold-like seeds (called 'old woman' in Marathi), cotton and silk cotton. They had seen these seeds fly. They brought these seeds to class and observed that they had wings, hair or cotton around them. *Interesting question* 6 was discussed here. (See page __ for pictures and names of some flying seeds.)

Students pointed out that some seeds, like grass and even coriander and millets like bajra and ragi, did not have hair or wings but were so light they could be carried by a breeze. Grass produces seeds in very large numbers and these seeds are carried easily by the breeze. This is one reason why grass grows everywhere. The same holds for weeds like parthenium ('congress grass'). One smart student commented that all seeds could fly - even a mango seed could be carried in a storm!

b. Take a seed that does not travel very well with the wind. What could you stick to your seed to make it blow away with the wind? Try some of your ideas.

Classroom experience

This activity was given as homework. Students tried a few ideas and also brought materials like bits of cotton, tissue paper, wool etc. In the class they were divided into groups. Using the seeds we had collected I prepared two packets for each group: one packet containing seeds that could fly and another with ordinary small seeds like coriander and mustard. By keeping the seeds on their palm and blowing students could find out how easily they could fly with the wind. Then they made their own constructions of flying seeds:



Many bacteria, viruses, spores and pollen are drifting constantly in the air (see pages 40-41 of the TextBook). Some seeds too are small enough to drift like this. Some seeds move well through air because their shape provides greater lift or lower drag - they might have fluffy hair like cotton and thistle, wings like drumstick, or some might hang on stalks attached to a hairy parachute. Seeds could be carried with the wind for hundreds of kilometres.
An extremely strong wind can carry even large animals! Gales at 200 km/hr have carried earthworms, salamanders, tortoises and kangaroo rats. Waterspouts can lift fish from the water and even these can be carried over long distances by the wind.

c. Watch the shape of a bird's body as it flies. Now watch how the wings are turned when the bird slows down to land (TB p. 28, WB p. 52).

If a bird swoops or dives very fast to catch something, you will see how the wings are folded close to the body.

Students' observations

Students recalled the birds they had seen flying, landing and diving. They had noticed the diving shape of kingfishers and seagulls. They had seen birds gliding without flapping their wings, and flying in wide circles while ascending. They showed with actions how birds fly, dive and land.

When a kingfisher dives to catch a fish, or a kite dives to catch a mouse or piece of food on the ground, it must move fast. The bird has to catch its prey and fly back up without stopping. The streamlined shape of the body, with wings folded back, helps it to move swiftly.

Birds fly by flapping their wings to control the lift and drag caused by air flow. All the feathers in the bird's wing move and twist together in beautiful co-ordination. Birds with long, narrow wings, like seagulls, get a lot of lift because of this shape of their wings. They can glide in a leisurely manner without flapping their wings much. Birds with short, broad wings, like crows,

need to beat their wings rapidly and fly faster just to stay up in the air.

When the bird comes in to land, it twists its wings so that they offer a broad surface to the wind. This is similar to the braking effect of the newspaper in Activity 3b.

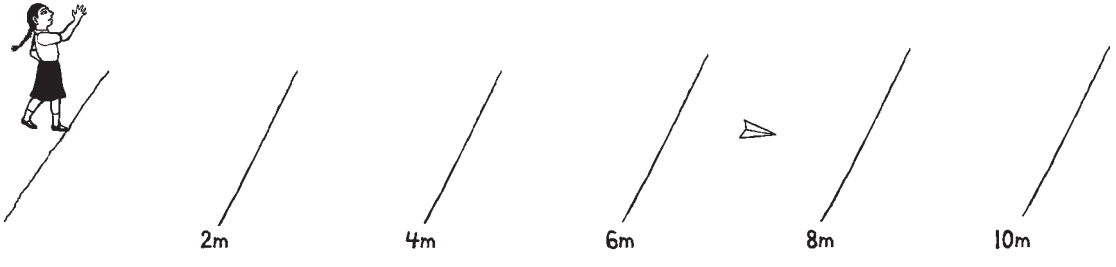
d. Play this game. Each of you take a sheet of paper of the same size. Fold your paper, crumple it, or roll it into any shape, without cutting or tearing the paper. Now stand in a line with some friends and throw your paper shape. Guess how far your shape will travel. Try it several times. Measure the farthest distance each shape goes (WorkBook page 52).

Classroom experience

This activity was done outdoors. Students made several shapes but most of the boys made aeroplanes. Though the girls did not know how to make aeroplanes, they did try. Some girls started with a house or purse and then folded it into an aeroplane-like shape. By the end of the activity most of the girls had learnt to make paper airplanes.

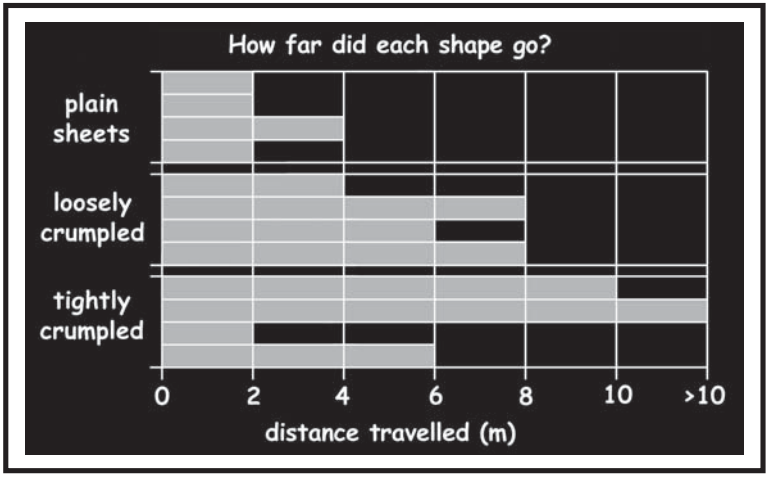
I drew one line on the ground for the students to stand and throw their shapes, and other lines at 2m, 4m, 6m, 8m and 10m from the first. One might also use convenient lines on a tiled floor. Students marked the distances for successive trials by seeing roughly where and between which two lines their shape landed (Table on page 52 of the WorkBook). In the time available only a few students could complete the activity, while others watched the demonstration and completed it as homework.

Back in the classroom the students reported the maximum distance travelled by their shape which I recorded on the blackboard.



BLACKBOARD WORK

Each of four groups threw one of each shape. This graph shows the results.



Students' observations

During classroom discussion students gave several reasons for some shapes going further than others. These responses along with my follow-up questions are given below:

1. Heavy shapes fell nearer. (All were made out of identical sheets of paper - could some shapes really be heavier? If in doubt, how would you find out?)

2. If air pushed more, the shapes went farther. (Would the air push them forward or would it slow them down? What did you find when you ran with the newspaper?)

(Observations 1. and 2. showed the presence of misconceptions. I tried to help the students to think more critically and test their guesses against experience.)

3. Shapes thrown with force went far. (What if you throw all the shapes with the same force? How would you try to keep the force of throwing the same? Does it matter which way you turn the shape while throwing?)

4. Some papers did not go far because they glided/ floated in the air for a long time. (What were the shapes that floated, but did not go far? Would these shapes go far if there was a wind? Try it and see.)

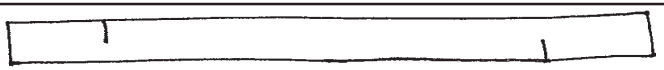
(Observations 3 and 4 pointed out some relevant factors - apart from shape - affecting the experiment. I encouraged the students to investigate further.)

5. Long, thin, pointed shapes went farther. (Try to make shapes that go further.)

6. It depends on how neatly they are folded. When there were gaps in folds, the shapes did not go far.

(Observations 4, 5 and 6 focused on streamlining of shapes. I discussed the similarity of these shapes with airplanes, rockets, fast cars etc. One student showed an interesting airplane design in which he curled one of the wings upwards and the other wing downwards. This airplane turned around after going some distance.)

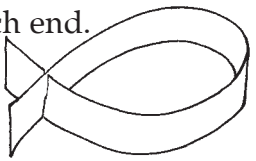
e. Make a spinning fish.



Take a strip of paper, 12 cm x 1 cm.

Cut two small slits on opposite sides, about 2 cm from each end.

Bend the paper strip and lock the slits into each other.



Throw the fish in the air (TB p. 28, WB p. 52).

Classroom experience

Students might have made these or other wind toys on their own. This is an easy example, taken from the book 'Toys and Tales with Everyday Materials' by Sudarshan Khanna and others. Several other examples are given in this and other books (see References, page 343).

The prettily spinning fish is easy to make. It can be done by just tearing paper (scissors are not necessary). Some students had trouble understanding the cuts. Although the above diagram (which I enlarged on the board) shows clearly that the cuts are to be made on two opposite edges, students tried making them on the same edge.

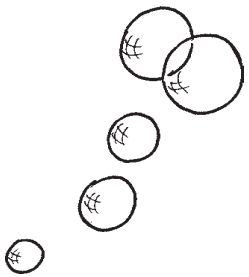
Think! Think!

What happens if the seeds of plants do not blow far away, but fall to the ground close to the plant?

There is not enough room for the plants to grow tall and the roots to spread. I pointed out that grass grows all over the place whereas large trees are fewer and grow further apart. A sapling under the canopy of a large tree does not grow very high.

Are there any similarities between the shapes of birds, fish and aeroplanes?

Birds, fish, boats, aeroplanes and racing cars all have streamlined bodies.



5. Air makes bubbles (2 periods; TB p. 29, WB p. 53)

a. Dip one end of a drinking straw in a bowl of water. Blow into the other end. Put some soap in the water and blow again.

What is the difference between the bubbles in plain water and those in soapy water? Try different kinds of soap, like bath soap, washing powder, or shampoo. Try to make bubbles that are bigger and that last for a longer time (WorkBook page 53).

Classroom experience

The activity was done in groups of five students. Each group filled two glasses of tap water and added a pinch of powdered soap to one of the glasses. Each student had his/ her own straw. While one blew the bubbles, the others made observations.

At first the students quickly went through their turn, till one girl thought of blowing slowly and steadily into the soap water, getting large bubbles which overflowed on to the table. The other students got very excited and began making lots of bubbles, and also many observations:

Students' observations

They noticed that soapy water made bigger bubbles which lasted a longer time than bubbles made in tap water. Detergent made better bubbles than ordinary soap. It was clear to students that they were blowing air to make bubbles - so these bubbles must be filled with air. Though the outer cover of each individual bubble is very thin, with so many bubbles the glass full of soap solution soon got used up.

Students gave innumerable examples of bubbles seen in plain water: on stirring or shaking water, on boiling it, air bubbled into a fish tank, tap water falling in a bucket, in waterfalls, in waves on the beach, behind a fast-moving boat, etc. Some interesting cases were, bubbles trapped inside ice, and bubbles seen around green water plants. There were also examples of bubbles in soapy water: having a bath, washing hair, clothes etc. Scrubbing, rubbing and shaking increased the foam - they realised that these were just different ways of putting air into the liquid.

There was some discussion about the difference between foam/ lather and bubbles. I asked students to look at lather under a magnifying glass. Foam is made of small bubbles sticking together. The larger bubbles in foam break sooner.

One student mentioned spit bubbles that children like to make with their lips! It is interesting to notice that spit bubbles are bigger and last longer than water bubbles. With toothpaste in the mouth, bubbles can be blown even larger. I asked students to try this during restricted times with washing-up afterwards!

> All this has to do with soap reducing the 'surface tension' of water. Adding glycerine to soapy water makes it even better for blowing bubbles. One might also experiment with adding sugar. Shampoo blows better bubbles than soap.

Guess what is inside all these bubbles!

Since the bubbles are formed by shaking or agitating some liquid, one might guess that the surrounding air has entered the liquid to make bubbles. When you blow to make bubbles, you know they contain the air that you breathed out.

6. Air makes sound (1 period; TB p. 29, WB p. 54)

a. Find different ways of making sound using different parts of your body. Make soft as well as loud sounds (WorkBook page 54).

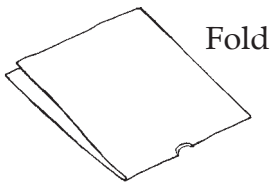
Students' observations

In bursting the paper bag students had found that air makes sound. (See discussion on pages 86-87.) Examples of sounds using your body: apart from talking, shouting and clapping, students suggested whistling, clicking tongue, laughing, sniffing, sneezing, coughing, burps and different sounds with the mouth and nose, slapping hands on cheeks, arms, thighs etc. and cracking knuckles. In all of these I told them that they were setting up a movement (vibration) in the air. The more vigorous the movement, the louder was the sound produced.

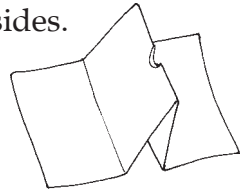
b. Make a paper whistle.

Take a piece of paper, 10 cm x 5 cm.

Fold it in half and tear out a hole in the centre.



Fold out the two sides.



Hold the whistle between two fingers and blow hard.

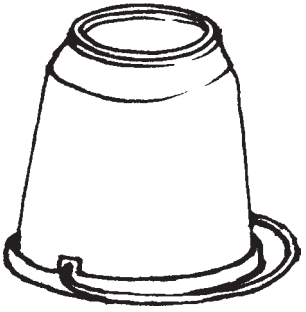
Classroom experience

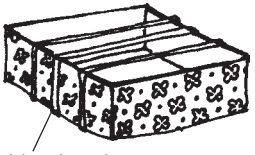
The paper whistle was easy to make. Students compared its sound to that made by air escaping through the narrow stretched mouth of a balloon. Another paper toy which students made on their own was a 'fatakdi' or paper cracker.

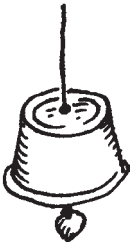
7. Air makes music (5 periods + homework; TB p. 29, WB p. 54)

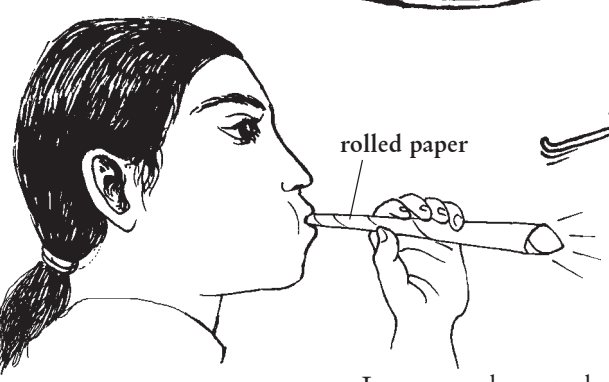
Preparation for activity

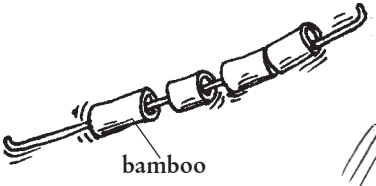
In preparation for this topic, students either found or made simple 'musical instruments' in which you had to blow air, beat a membrane or pluck strings. For 'blowing' they brought whistles, pen caps, comb with tissue paper and a flexible corrugated tube which made a humming noise when whirled around; for 'beating', spoons, cans, lids, half coconut shell covered with paper, bowls of water and two long thin leaves held together at two ends and flapped; for 'vibrating strings', metal wires and rubber bands.

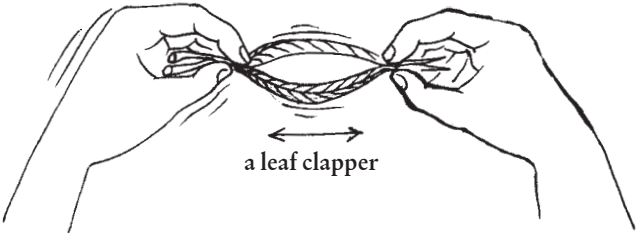










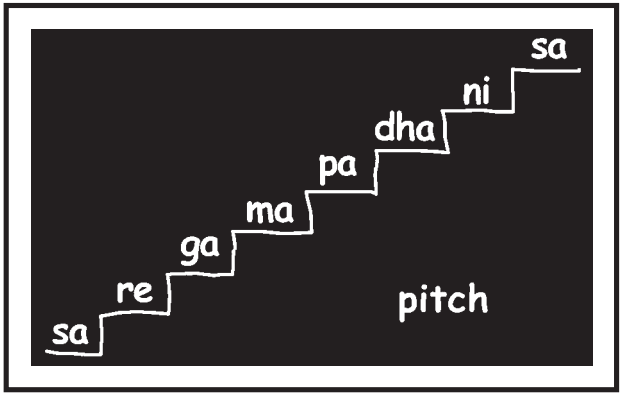


I suggested to students that they attend folk, religious or classical performances of music or dance, and observe and listen to the musical instruments played in them.

a. A musical sound can be loud or soft. It can also be high pitched or low pitched. Sing loud, sing soft, sing high pitched, sing low pitched. Now sing loud and low pitched.

Practical hints

The musical scale should really be introduced in the music class. I found however that students had learnt mostly patriotic songs, prayers and bhajans but did not know the musical scale (sa re ga ma pa dha ni sa). I wrote these notes on the blackboard along an ascending staircase.



In addition to the singing activity, I used a toy mouth-organ to demonstrate 'high' and 'low' pitched notes. I blew two notes and asked students to say which one was higher pitched (initially they used the terms 'thin sound' and 'thick sound' for high and low-pitched sounds). Later they were also able to recognise when two sounds were of the same pitch but one was louder or softer. Thus they could distinguish between 'pitch' and 'loudness'.

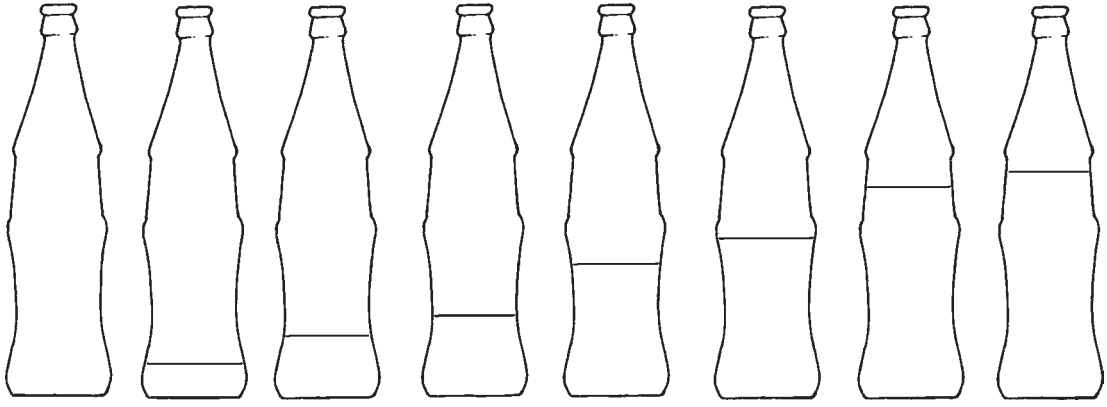
b. Blow across the mouth of an empty bottle, or strike it with a spoon. Add some water and blow or strike again. Hear how the sound changes.

Which sound is higher in pitch?

Classroom experience

Students had brought different kinds of bottles and jars. They tested the sound made by blowing above the bottle with and without water. They noticed that with the water the note was higher than without the water. Working in groups, they put together two or three identical bottles, ordered them in increasing and decreasing pitch of musical notes, and correlated the pitch with the height of water.

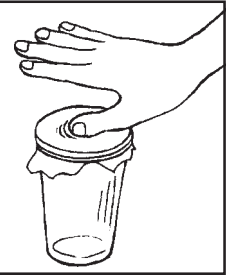
c. Collect eight empty bottles of the same size and shape. Fill them with water up to different levels. Arrange the bottles in order of water level. Blow across the top of each bottle or tap them with a spoon. Adjust the levels of water until you get a musical scale (TB p. 30, WB p. 54).



Classroom experience

We borrowed 8 identical soft-drink bottles from a cold-drink shop. After some trial and error I got the musical scale to sound like sa, re, ga, ma, pa, dha, ni, sa. The approximate levels of water were as shown in the picture in the TextBook. On the next day one student reported that he had tried blowing across the mouth of a soft drink bottle periodically as he was drinking it.

d. Stretch a large torn balloon over the mouth of an empty glass. Fix it in place with a rubber band. Tap, rub, or pluck it to make different sounds.



e. Pluck a stretched rubber band to make it vibrate. Then stretch the rubber band around an empty box and pluck it again. Which of the sounds is louder?

Classroom experience

d. and e. were done together. They demonstrate the sound-box of a musical instrument. The box amplifies the vibration of the stretched membrane or string: the rubber band gave a louder sound when stretched around a box rather than around a coat hanger. The larger the box, the louder was the sound.

f. Bring some musical instruments to class. Look carefully at each one. Does it make music when you blow it, when you beat it or when you make its strings vibrate?

Try to identify the musical instruments that are shown on pages 56-57 in your WorkBook. Sort them into the three groups: blowing, beating and vibrating strings.

Which musical instruments have air inside them? Guess which parts contain air.

Classroom experience

Students could name many musical instruments though they had not seen or listened to all of them. I wrote these names in three groups on the blackboard and after a few examples asked what was common to each group.

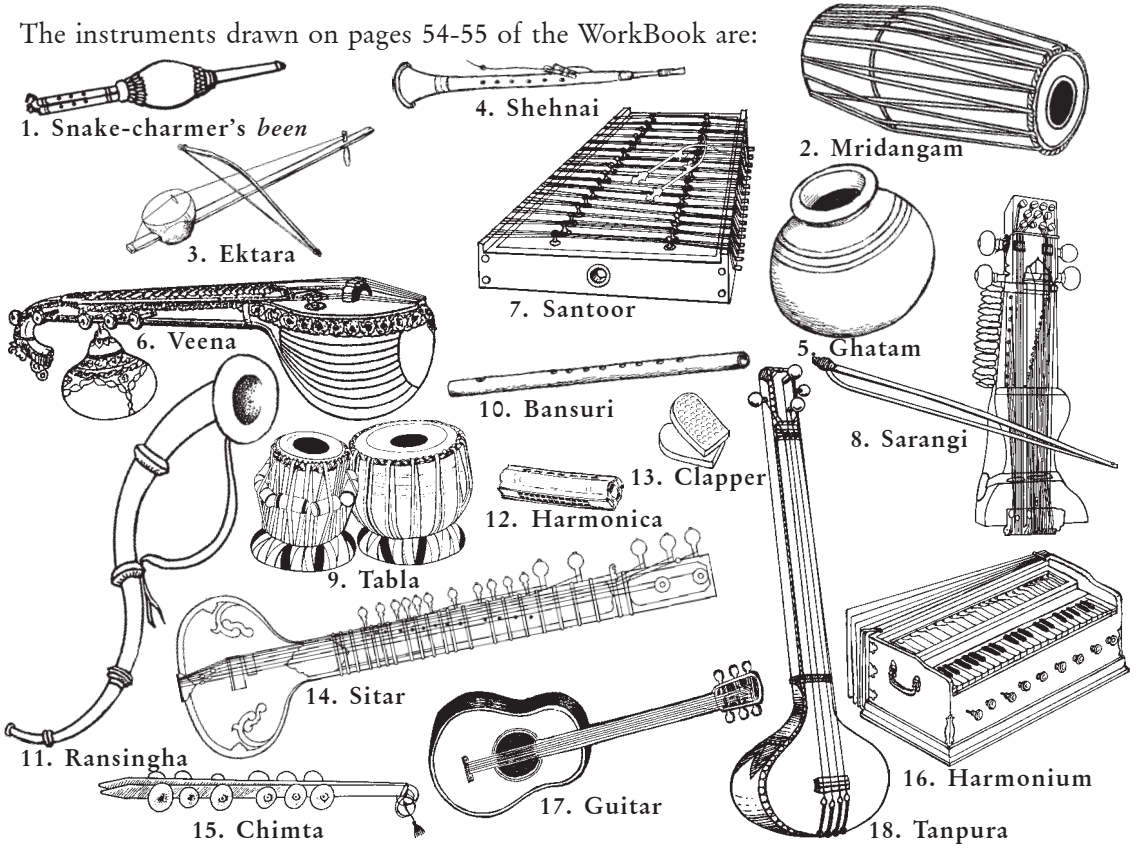
Group A: flute, bansuri, nadaswaram, shehnai, snake-flute, piccolo, trumpet, saxophone, bugle, mouth organ, organ, harmonium ...

Group B: tabla, dholak, mridangam, ghatam, nagada, drums, bongo drums, triangle, tambourine, xylophone, piano, santoor ...

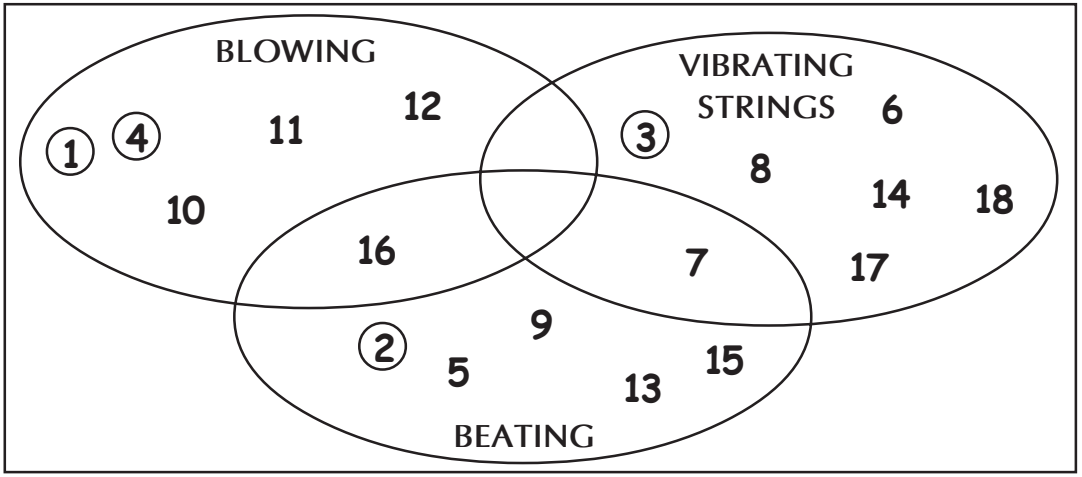
Group C: guitar, sitar, veena, tanpura, sarod, sarangi, violin, harp ...

Group A consists of instruments in which you blow air. The Group B instruments are beaten or struck to make a sound. The Group C instruments have strings which vibrate on plucking or rubbing with a bow, like a violin. Most of these instruments have an air box which makes the sound louder. The electronic keyboard or synthesiser produces sound through an electric circuit - it does not belong to any of these groups. All sound reaches our ear due to vibrations of the air between the instrument and the ear.

The instruments drawn on pages 54-55 of the WorkBook are:



These instruments can be sorted into the three groups as follows. Previous practice with *Figure it out* exercise no. 5 of Chapter 1 (see pages 60-62) plus some familiarity with musical instruments would be helpful:



g. Design and make your own musical instrument (Workbook page 55).

Several simple instruments had been made already. One was a large box with rubber bands of different thicknesses stretched across it to produce sounds of varying pitch.

Know these words

vibrate vibration

Classroom experience

The words 'vibrate' and 'vibration' were introduced in the above activities. The rubber band in 7e. could be clearly seen vibrating - moving fast from side to side. I told students that sound is produced by vibrating things. Often these vibrations may not be visible but they are there. You can stop the sound of a bell, gong or string by holding it tight, thus not allowing it to vibrate.

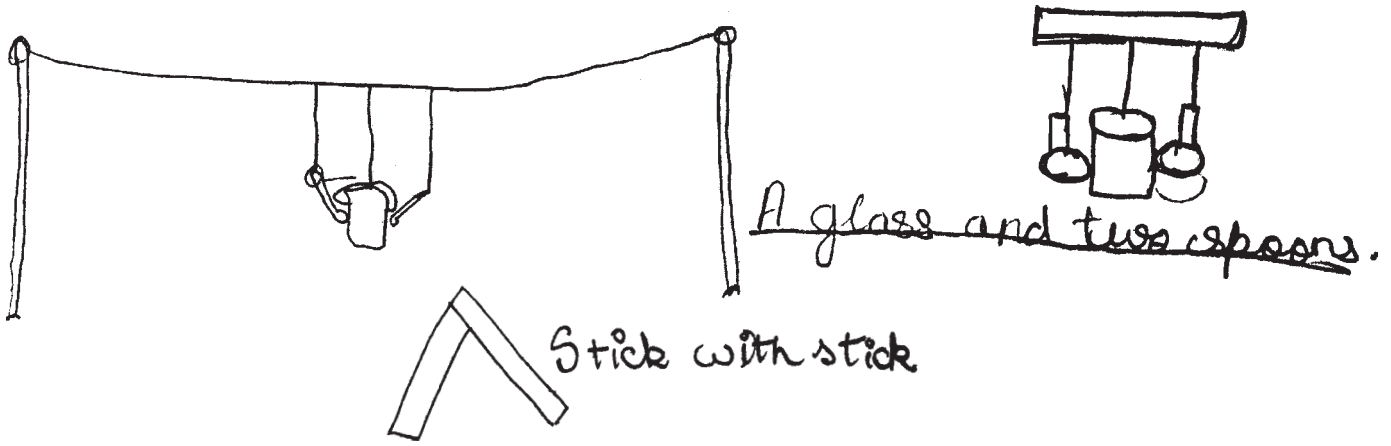
EXERCISES (5 periods + homework to be done in parallel with classroom activities and discussion)

Observation-based exercises

Name and Draw (WB p. 58)

1. Something moving in the air (draw it so that people will know it is moving).

2. Imagine a musical instrument that will play when the wind blows on it.



Students also mentioned things that make a sound when the wind blows on them like, an open window, fluttering curtain, leaves in a tree, sea waves and a microphone.

Interesting questions (WB p. 59)

1. When you pour water on dry soil, do you see bubbles? Why?

There is air between the lumps of mud. When water goes in the soil it fills these air spaces, pushing the air out. This air makes bubbles in the water.

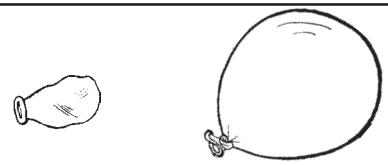
2. Name some places where you have seen bubbles.

See examples on page 103.

3. On a calm day, is it easier to run with an open umbrella or with a closed umbrella?

A closed umbrella. A wind would help running in one direction but slow you down in the opposite direction. The question was discussed after the newspaper relay race.

4. Suppose you throw these two balloons. There is no wind. Which balloon will travel further?



Classroom experience

The empty balloon. Since most students guessed the opposite, I asked them to try it out. Interestingly, students tended to vary the strength of throwing so as to confirm their own predictions! However, they were corrected by other students. The results were surprising for all. If the ceiling fan was on, the full balloon was blown around and went further. If not, the empty one travelled further. I had to remind them of the condition that there is no wind blowing.

5. You have two sheets of paper: one unfolded, the other crumpled into a ball. If a wind blows, which sheet will travel further?

Classroom experience

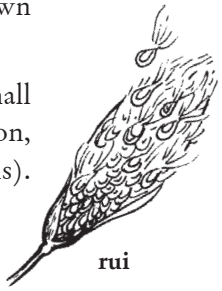
The unfolded sheet. Here again the students' predictions varied. In Activity 4d. the shapes had been thrown in the absence of wind - then the crumpled paper had travelled further. When the two were dropped, the latter fell faster. But with the wind blowing, the unfolded sheet travelled further.

6. Name some seeds that are carried by the wind.

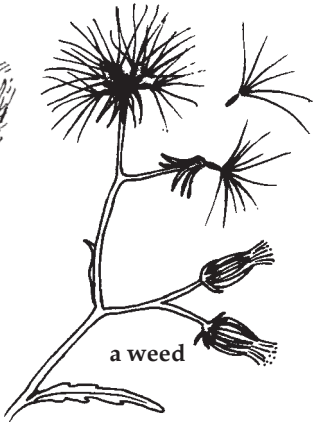
Students found common names or gave their own names for plants or seeds.

marigold

Seeds with hairs or fibres: marigold or similar small plants found as weeds (family Compositae), cotton, different kinds of silk cotton, *ak* or *rui* (Calotropis).

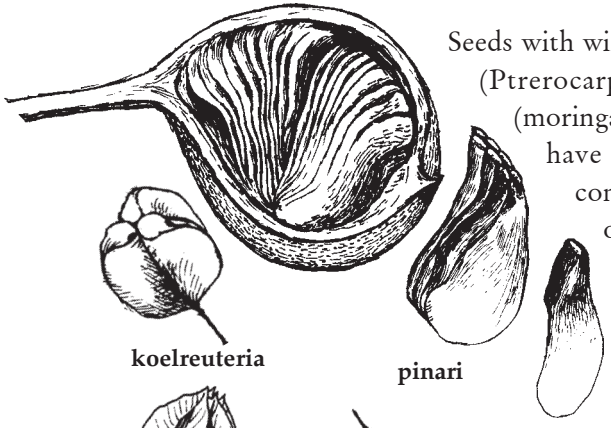


rui



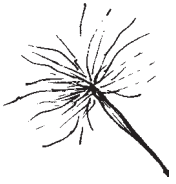
a weed

Seeds with wings: ain, arjun, Indian kino (Ptrerocarpus), tulip tree, drumstick (moringa). Although drumstick seeds have wings they are probably not commonly dispersed by wind. Some other trees with winged seeds like champa and Indian cork may not bear fruit in all regions.



koelreuteria

pinari

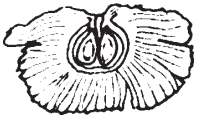


a grass

Very light seeds: many grasses, coriander, parthenium (congress grass)

arjun

sissoo



ullu

another grass

Observation and language based exercises

Classroom discussion (WB p. 59)

The discussions were done along with Activity 1.

1. In which of these places is there air: in a closed cupboard, in the soil, in water, inside your body, inside a brick?
2. Is there any place that is empty? Which does not even have air? Make your own guesses.

Students' alternative conceptions

At first the students said that air is everywhere - except one, who said that there is no air on the moon. It turned out that they had uncritically memorised the phrase 'air is everywhere', but when questioned closely they contradicted their own statement. One student initially thought that there was no air in an upside-down glass held up in the hand; another thought that if the glass was placed upside-down on a table there would be no air in it. Another said, "There is no air in the glass: in Class 2 the teacher put an empty glass over a burning candle and the candle went out!"

I realised yet again how easy it was to do a memorable activity but for students to carry away the wrong impression from it! I asked whether the bag in Activity 1a. would fill with air if it was held upside down. Since we had the bag handy we tried it, and found it still had air.

Getting students to think

Other surprising answers were, there is no air in the corner of a closed cupboard and in a deep hole in the ground. Many students said that there is no air in the soil, in water, and inside our bodies. In all of these examples, other students in the class gave counter arguments, leading to a lively discussion. When necessary I too contributed some arguments:

"Air must go in through cracks or when we open the cupboard." One student had heard that someone was once shut in a cupboard and died of suffocation (lack of air). This is an important warning, often given by parents. I told the children that air does get

in through cracks, but not fast enough for a person to continue to breathe (we take in about 500 ml. of air with each breath). Small animals like ants, silverfish, cockroaches and lizards who need less air, can live in cupboards.

Similarly, we know that many creatures live and breathe within the soil. Even roots of plants need to breathe air. If soil remains full of water for a long time (as in a flood), then the plants die. We see air bubbles coming out of the soil when we pour water. I told students that mangroves, which are plants inhabiting marshy places, have roots which grow up into the air for breathing. But unless there are holes or spaces within the rocks that are below the soil, air cannot reach very deep down into the earth.

There is air dissolved in water. It bubbles out when we heat water (before the water boils we see these bubbles). Fish are able to take in this dissolved air. Some students had noticed bubbles on putting a piece of brick in water. They said that there must be air inside a brick and so inside a brick wall too.

It needs time and patience to get students to think critically. One has to continuously challenge them to go beyond their conventional verbal knowledge, by using experience and commonsense wherever possible, while realising the limitations of these too. In this process, we should be careful not to simply replace one kind of verbal knowledge by another.

For example, after the above discussion students got the idea that air is in fact 'everywhere', that is, in the most unlikely places too. But now they started to over-generalise and answered "Yes" to any question of "Is there air here?" I had to tell them that (with the exception of porous materials) there is no air inside a piece of metal or plastic; that although there is air in those parts of the body that are open to the atmosphere, like the respiratory and alimentary (food) canals, there is no air for example, within the bones and muscles.

3. Suppose you close the mouth of a pichkari that is filled with water and push the piston. Will the piston move? Is this different from what happened with air? Why or why not?

The guessing and demonstration was done with Activity 2. We found that we could not squeeze water in the way we were able to squeeze air.

What's same? What's different? (WB p. 60)

1. Give two similarities and two differences between:

   a. Air and water

Both occur naturally, flow, are colourless and are essential for life; both can be filled in balloons. We can see water but cannot see air; water flows from high to low level but air flows everywhere; water is normally a liquid but air is a gas (a number of differences follow from properties of liquids and gases); air brings wind, storm and cyclone but water brings floods.

   b. Air and mud

Both occur naturally; land plants (so all land life) need both; we play with both. Air is gas but mud is solid (a number of differences follow from properties of gases and solids); air is everywhere on earth but mud is not.

2. Look at these sets of things:

   a. balloon, bubble, football, cricket ball

   Why is the cricket ball different from the rest?

All except the cricket ball are filled with air.

   a. vulture, frog, butterfly, aeroplane

   Why is the frog different from the rest?

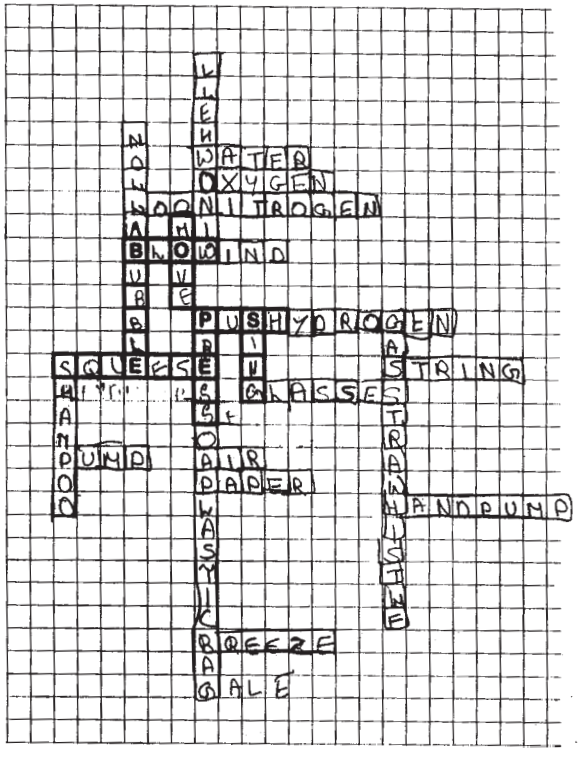
Only the frog does not fly.

Language-based exercises

Play with words (WB p. 61)

1. These action words describe what can air do and what you can do to air: move, push, press, squeeze, blow, bubble, sing ... Write all these words in the crossword on page 61 in your WorkBook. See how many more words you can add to the crossword.

Many students did not know how to make a crossword, and did not realise that they should use verbs that can fit into the sentence, "Air can ....."



BLACKBOARD WORK

The students contributed to a Blackboard Game, taking turns to fill in words in the grid.

2. Finish this poem about air using as many of the crossword words as you can

Talk to me, air!
Knock on the blue door
Tumble inside, air!
Lift my papers gently
Tickle my soft nose, air!

Students' poems:

Air come in my mouth
Air come in my nose
Let me breathe
Let me grow

O air you go so high
You flow everywhere
I want to fly like you

Air pick up the dust
Fill the balloon
Make the parachute fly

2. Here are some 'sound words'. Think of some others. Try to make these sounds.

bang! trrnng hum squeak plop sshroookh

Some common sound words are: clang, crash, thud, wham; ring, jingle, tinkle, plonk; screech, crunch, clatter, rattle, chatter; whoosh, whistle, rustle, beep, buzz, trill; hum, drone; shout, bellow, roar, growl ... Students should make up their own words too.

Figure it out (WB p. 62)

With some of these instruments you make music by blowing air from **inside** your body. In others you use air that is **outside** your body. Separate these two kinds of musical instruments.

flute	tabla	shehnai	guitar
veena	harmonium	sarangi	whistle

Music made by air blown from our lungs: flute, whistle, shehnai

Music made by air from outside our body: veena, tabla, harmonium, sarangi, guitar

Ask a question (WB p. 63)

Students' questions:

1. What makes the wind blow?

When air is heated by the sun it becomes light and rises. The surrounding cold air comes to take its place. This moving air is called wind.

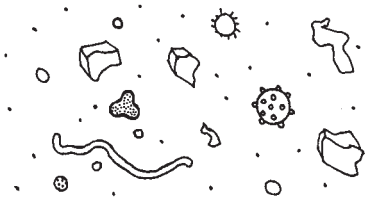
2. Can a sailboat or ship only move in the direction of the wind?

Sailboats used almost four thousand years ago on the river Nile were of this type. The Nile river flows from South to North, while the wind there blows from North to South. If the boat had to go South, the sail was put up but if it had to go North, the sail was taken down. Later the Chinese people discovered how to make sails which could be moved or tilted in order to travel in any direction, even a direction opposite to the wind.

DID YOU KNOW?

Air is everywhere around the earth. But if you climb up a very high mountain, there will be less air. If you go on a rocket into outer space, you will come to a place without any air.

There is no air on the moon.



CHAPTER 4 What's in the air?

STORY (half period)

Something in the air (TB p. 34)

Apu and Mini were playing in the big ground with trees around it. They loved to run, jump and play in the clean fresh air.

There's something in the air
That lets me live
It lets me breathe
Makes me feel so good!

But today some people came to the ground to burn dry leaves and garbage. The playground was full of smoke. Mini and Apu soon decided to go home.

There's something in the air
That chokes me up
That smells so bad
Makes me sputter and cough!

As they walked home they wondered, "Does it have to be like this?"

What can we do to have clean, fresh air always?

Students' observations

Students added to the story their own experiences of burning garbage. They knew that wet leaves and wood produce more smoke than dry ones. (See *Students' questions*, page 149.) They also knew that some materials like rubber and plastic, when burnt, produce foul-smelling and suffocating fumes. They listed places in their locality which they felt had

polluted air (close to the highway, near the sewage canal and the oil refinery). We discussed these experiences later, in Activities 4-6.

I told them to read the questions in *Ask and find out* and to think, "what could **they** do to produce less garbage and to reduce pollution?"

ACTIVITIES

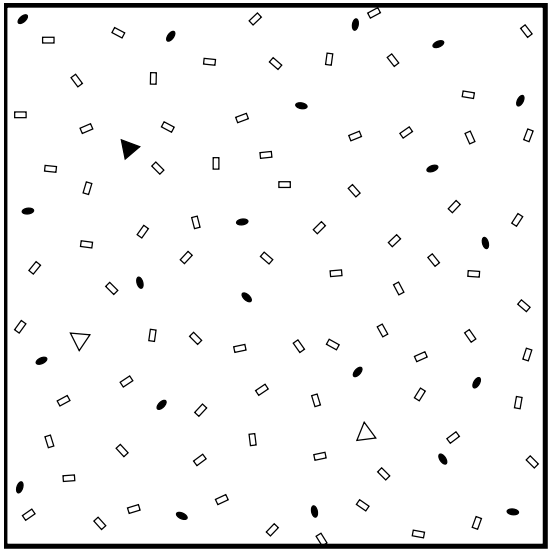
What is air? (TB p. 35, WB p. 64)

1. Air is made of different kinds of gases. (2 periods)

a. The four main gases in air are called **nitrogen**, **oxygen**, **carbon dioxide**, and **water vapour**.

These four gases have no colour, no smell, no taste.

Each gas is made of very tiny particles called molecules. Molecules are so small that we cannot see them with an ordinary microscope.



This is an imaginary picture of air:

The rectangles show molecules of nitrogen.

The black ovals show molecules of oxygen.

The black triangles show molecules of carbon dioxide.

The white triangles show water molecules.

Look at the picture to answer these questions:

Air consists mainly of which kind of gas?

What is the second most abundant gas in air?

In Chapter 3 students were introduced to the idea that air is a material substance. In Chapter 4 they are exposed to the concept of 'gases'. To get a concrete picture of a gas they have to understand that (like all materials), a gas is made up of particles! Remember, historically these ideas took several centuries of painful effort by the most powerful minds; surely we cannot expect students to understand them immediately?

Students' alternative conceptions

I started by asking students what they knew about 'gases'. I found that they had heard about 'gas stove,' 'gas balloons' and 'gas in the stomach', but some also thought that 'sunlight' is a gas. One student said that a light bulb gives out gas. I had to tell them that light is not a material substance, it is a form of energy - this will be introduced in Class 5.

I also clarified that the symbols on page 35 were not meant to show the actual shape of the molecules.

> The picture roughly indicates the proportions of various gases in the air. Almost four-fifths of air (78%) by volume, consists of nitrogen gas. About one-fifth (21%) is oxygen. The rest of the air consists of carbon dioxide (.04%), water vapour and a few inert gases, mainly argon (almost 1%). The proportion of water vapour in air varies a lot from place to place and season to season. Monsoon air may contain about 4% - 6% water vapour by volume.

Additional activity

Proportions and percentages are difficult and abstract concepts for students of Class 4. An activity with concrete materials might help them to understand this particular situation. For example, make a mixture of say, 78 grains of rice + 21 grains of a dal + some bits of grains to represent the remaining gases.

b. Fill a balloon with carbon dioxide: get a bottle of soda or some other aerated drink. Open it and quickly put a balloon over the mouth of the bottle. Shake the bottle. Watch the bubbles rise up. They are full of carbon dioxide (WorkBook page 64).

Why it happens

Carbon dioxide dissolves in water under high pressure to form soda water. When we release the pressure by opening the bottle, the gas bubbles out of the liquid. Shaking the bottle helps to start a few small bubbles into which more carbon dioxide then enters, creating larger bubbles.

Practical hints

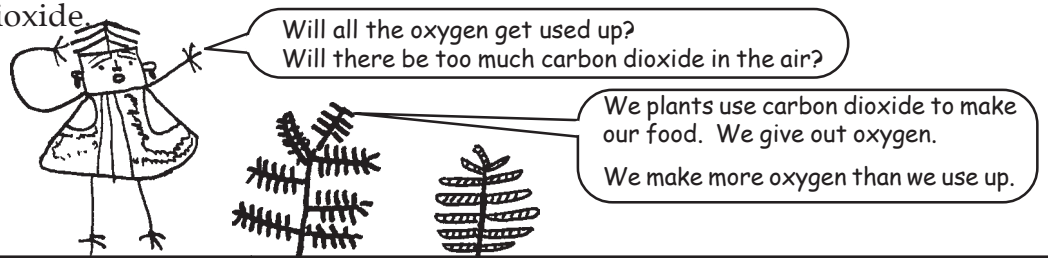
Before doing the activity I stretched and blew up the balloon a few times so that it was easy to inflate. Even so, the pressure of the carbon dioxide coming out of the bottle being low, initially the balloon was not blown very big. Starting out with cold soda and gradually warming the bottle helped to release the carbon dioxide. Finally, with shaking the bubbling increased dramatically. Students were absolutely thrilled.

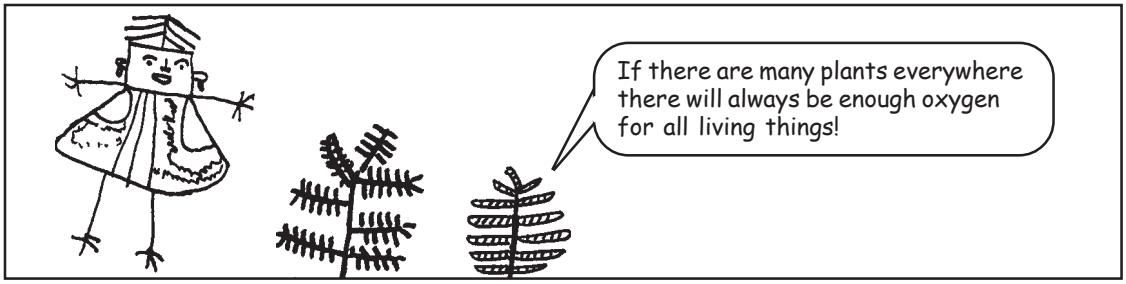
For better collection of carbon dioxide one could put some vinegar in a bottle and baking soda in a balloon. Open the bottle and quickly fit the balloon over it. Then invert the balloon, dropping the baking soda into the vinegar. The vinegar will react with the baking soda to produce carbon dioxide.

2. Living things use gases (2 periods; TB p 36)

a. All living things need to breathe air. Without air they would die.

All animals and plants use up oxygen from the air and give out carbon dioxide.





All animals and plants need oxygen gas and give out carbon dioxide as a waste product. The cartoon is meant to highlight the fact that green plants (besides using up carbon dioxide) also **make** oxygen, which is more in quantity than the oxygen they use up. Green plants are our only source of oxygen. It is only because of them that we are able to breathe!

In Chapter 7 we will learn that green plants, especially trees, are also crucial for preserving ground water on which all life on earth depends. I constantly try to convey to students this strong message about the importance of trees and plants.

> Most living things need oxygen to live. But some bacteria and other micro organisms live entirely on organic matter; many others use nitrogen and carbon dioxide from the atmosphere. These bacteria can only grow in the absence of oxygen!

Students' alternative conceptions

The gases we breathe in and out

> When we breathe, air goes through our nose and mouth into our lungs. Oxygen from this air is absorbed into our blood and carbon dioxide is given out. Students often imagine that somehow we breathe in pure oxygen and breathe out pure carbon dioxide. Even many adults think that we use up all the oxygen that we breathe in. In fact, the proportions of the three main gases in normal air and in breathed-out air are as shown in the following table.

Percentages of different gases in normal air and in air we breathe out

Gas	Normal air	Breathed-out air
Oxygen	20.96%	15.8%
Carbon dioxide	0.04%	4.0%
Nitrogen	79.00%	80.2%

The nitrogen is breathed out unchanged and so is most of the oxygen. Mouth-to-mouth artificial respiration for accident victims works only because even the breathed-out air has quite a bit of oxygen. (The volume of nitrogen breathed out is the **same** as that breathed in. The Table shows its **proportion** higher in the breathed-out gas volume because some of the oxygen is converted to water rather than to carbon dioxide.) The breathed-out air has more water vapour and droplets than the air breathed in.

b. We need to breathe! Close your mouth and hold your nose shut.

Count in your mind, "tick tick one, tick tick two ..." For how many seconds can you keep your nose and mouth shut? (WorkBook page 65)

Preparation for the activity

In Class 3 the students had learnt to estimate seconds by "tick tick counting". Now I asked them to recite "tick tick one, tick tick two ..." along with me in the proper rhythm, so that they reached "tick tick five ... ten ... " etc. in 5, 10, etc. seconds according to my watch. They estimated the number of seconds needed for various activities, like, taking a pencil out from their pencil-box, blowing a balloon and cleaning the board and (at home) brushing their teeth, drinking milk and filling a bucket of water. After estimating / guessing the times, they actually checked their estimates which, they found, improved with practice.

Some problems

Most students found they could hold their breath for 4-7 sec though some claimed they could hold it for several minutes. It turned out that these students were breathing quietly and imperceptibly, without even realising that they were doing so! Holding one's breath is an unpleasant experience that students perhaps avoid, though unknowingly. I sympathised and told them that we might stay alive without food for a few weeks, without water for a few days, but if we did not get clean air with enough oxygen we would die within a few minutes!

> The atmosphere is a layer of air that surrounds the earth. This layer gets less dense with increasing height. Although the atmosphere extends up to a height of about 100 km, the air at 4 km above sea level is so thin that breathing is uncomfortable. At about 5 km most people would die without their own supply of air. Some mountaineers do climb to above 7 km without carrying oxygen. They have to climb slowly, resting to let their body acclimatise to the height. During this rest, the body produces more red blood cells, thus increasing the intake of oxygen from the lungs into the blood.
>
> Over several generations people can adapt to living in high mountains. People in Tibet and in the Andes live at a height of 5.5 km or more where the atmospheric pressure is half of that at sea level. They have a larger volume of blood in their bodies and more red blood cells for every litre of blood. Besides this, they have developed a larger size of lungs and large alveoli (small sacs in the lungs into which inhaled air enters) to absorb more oxygen. They also have a large heart and a short body which make it easier for the heart to pump blood everywhere.

Think! Think!

All animals need oxygen. How do fish get oxygen?

Classroom experience

The question was meant to begin a process of thinking: the answer is given later in the TextBook in Chapter 6 *Did you know?*. Some students knew the fact that there is oxygen in water. Others used their knowledge about land plants to guess that the water plants might be making oxygen which is then used by water animals. However, none of them could say why fish can take oxygen from the water but we cannot do the same. I felt it was good to have some questions remain unanswered so that the information, when it came, became more meaningful.

3. Air inside our bodies (2 periods; TB p. 37)

a. Blow on your palm. Where is this air coming from? For how many seconds can you keep blowing out? (WorkBook page 65)

Students could blow out continuously for 5-10 seconds, a few seconds more than the maximum time they could hold their breath.

b. Blow air into a balloon. Hold the balloon and release its mouth.

What do you feel? What do you hear? Where did the air in the balloon go?

We can feel the air in the balloon and hear the sound it makes. When the air in the balloon comes out it mixes with the surrounding air.

Think! Think!

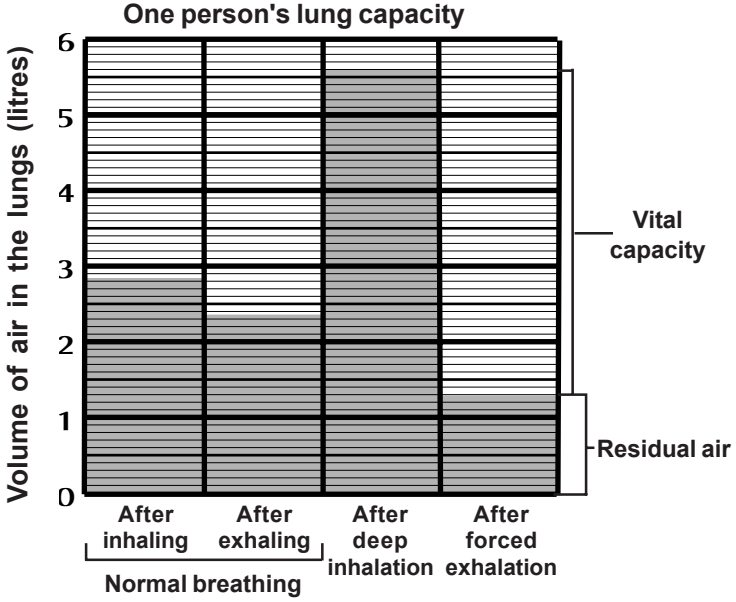
You blew air into a balloon. Where was this air before it went into the balloon? Do you think it was somewhere inside your body?

How many balloons can you blow up one after another? Where will all that air come from?

Students guessed that this air must come from inside their body/ chest/ lungs. They noticed while blowing up a balloon that they had to stop every few seconds, take a deep breath, and then blow again. They were taking air into the body from outside and then

blowing it into the balloon. They also noticed which parts of their body moved when they took deep breaths (throat, chest and abdomen).

Our lungs normally contain about 2.5 litres of air. With each normal breath we take in about half a litre of air and breathe out the same volume. If we exhale forcefully, another about one litre of air might come out, leaving just 1.5 litres of residual air which is always there in the lungs as long as we are alive. This air keeps the lungs in their normal shape.



Normally we use only a small part of our potentially large breathing capacity. A deep inhalation can take in about 3 litres of air. The 'vital capacity' of the lungs is found by measuring a forced exhalation following a deep inhalation. Vital capacity in normal adults varies from 1.5 to 7 litres, depending on the person's body size, age, state of health, yoga or deep breathing practice, etc.

4. **Where do different gases come from?** (2 periods + homework; TB p. 37)

From this Activity onwards we take up the idea of air pollution. Natural events like volcanic eruptions, forest fires, wind storms and decaying matter do cause air pollution. But these natural events being relatively infrequent and spread out widely over the earth, the dust and poisonous gases produced by them do not pose a major threat to life. On the other hand, the human sources like those described 4d. and 4e. emit large quantities of pollutants in relatively small areas (like cities), thus producing severe consequences for life. Some of these pollutants stay in the air for many years, react with each other to form more poisonous products, and travel all around the earth with the wind and the rain.

a. Living plants make oxygen. Animals make carbon dioxide (WB p. 66).

This sentence is meant to recall what students have learnt earlier about production of Oxygen and Carbon dioxide by living things on the earth. Since when has this production of gases been going on? I thought students might like to hear the story. In this story I introduced a few names of other gases as: hydrogen (the gas in very light balloons - it burns), methane (the smell of rotting *gobar* - it burns in air too), ammonia (an onion-like smell) and hydrogen sulphide (smell of rotten eggs). We could not have remained alive on this early earth, but we can imagine it must have been a very hot and smelly place!

The earth was formed about five billion years ago. During the first billion or so years of its existence the atmosphere probably consisted largely of methane and ammonia with some hydrogen sulphide, hydrogen and water vapour. A number of chemical reactions took place, helped by energy from the sun and volcanic eruptions on the earth, resulting in continuous changes in the composition of the atmosphere. Nitrogen and carbon dioxide for example, came out of volcanoes.

Early living things, like bacteria and blue-green algae, did not need oxygen to live. They used methane, hydrogen and hydrogen sulphide. However some of them had chlorophyll and carried on photosynthesis, using up much of the carbon dioxide and producing oxygen. If it was not for the early plants, there would be no oxygen on earth and no life as we know it!

b. In Chapter 10 you will find out how things decompose (rot). When plants and animals die they decompose. Decomposing things give off gases as waste. One of these gases is carbon dioxide.

Decomposing things give off other gases too. You can smell some of them.

Name some decomposing things that give off gases.

Students' observations

Though students could give many examples of rotting things that they had smelled, they were surprised to know that rotting releases gases.

Many gases are produced by the decomposition of dead plants and animals. The major gas products are carbon dioxide and methane. In a biogas plant, a mixture of gases produced by rotting things is collected and used as fuel. Methane gas produced by decomposing sewage and animal dung can be used for cooking and lighting homes. Sewage pipes contain methane gas - it is dangerous to enter a closed sewer with a light as the mixture of methane and oxygen can cause an explosion.

There are characteristic bacteria which consume certain elements in the dead plant or animal and produce related gases. For example, sulphur in eggs and some leafy vegetables is consumed by some kinds of bacteria which then liberate sulphur dioxide or hydrogen sulphide (the gas which give a charateristic smell to rotten eggs). Nitrogen in protein foods is used, along with carbon dioxide, by bacteria which then liberate nitrogen dioxide.

c. Go to different places in your home, school or outdoors. You could go to a kitchen, a bathroom, a garden, or a garbage dump. Close your eyes and sniff. Which of these places can you recognise by their smell? How do the smells get inside your nose?

Students' observations

Students recognised several places by their smell: kitchen (vegetables and ripe fruit being cut, brewing tea and coffee, boiling, frying, roasting and burning of various foods eg. seasoning curry and burnt milk); bedroom (naphthalene balls, talcum powder); bathroom and toilet (soap, chlorine, other disinfectant); verandah (plants, wet soil); garden (flowers, freshly cut grass); street (dust and smoke); railway station (food vendors, fish, lorry full of chicken, hay and jute packing); restaurant; hospital etc. These were largely urban examples - in a rural environment they would be different.

I tried to distinguish between solid particles, liquid droplets and molecules of a gas, which might all be in the air and could lead to sensations of smell. In cooking food, along with steam, some gases go into the air. You smell things when these gases enter your nose. Perfume is liquid in the bottle but the odour of perfume is a gas.

d. Burning things use up oxygen. They produce carbon dioxide and other gases. You cannot see these gases. Many of them are poisonous.

Can you smell the stove or fire in your kitchen?

Stand around the teacher in two circles. The teacher will light a match. When you hear the sound of striking the match, start counting seconds, "tick-tick one, tick-tick two ...". As soon as you smell something, raise your hand and note the number of seconds the smell took to reach you.

Students' observations

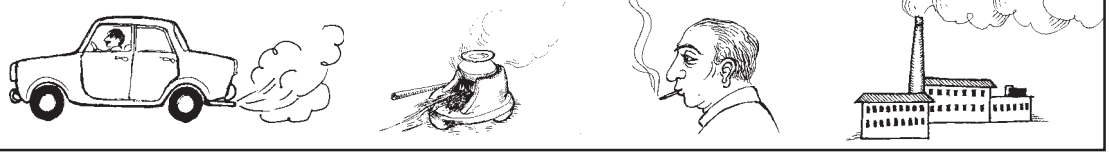
Students knew that you can smell a wood, kerosene or paraffin stove but not a gas stove. Often it is the smell that makes us aware of certain gases being in the air. Smoke from say an *agarbatti* or *dhoop* consists of several kinds of gases besides carbon dioxide. The visible part of smoke consists of small solid particles. These are unburnt particles of the agarbatti.

> All fuels burn by combining with oxygen from the air. When cooking gas (LPG) burns it forms mostly carbon dioxide and water vapour which are odourless and harmless in a well-ventilated kitchen. (You can see condensed water from the gas flame in the initial few seconds after you keep polished cold vessel on the flame.) On the other hand, burning of kerosene produces poisonous gases like carbon monoxide particularly if there is insufficient supply of oxygen.
>
> LPG and kerosene are both 'fossil fuels' - see page 133. The worst kind of indoor pollution however is found in houses with *chulhas* which burn wood, straw or dung - see pages 134 and 148.

Classroom experience

In the match-striking activity the times ranged from 2 secs. to 16 secs.. Unexpectedly some students in the outer circle got the smell earlier than those in the inner circle. Since air around us is always moving it may happen that the smell / gases travel faster in some particular direction. Also, some of us have a keener sense of smell than others, either genetically or through practice. If students are interested they might do their own experiments to check individual sensitivity to smells.

e. Factories make different kinds of gases. They also give off gases as waste. Here are some ways poisonous gases get into the air:



Look for ways that poisonous gases might be getting into your air.

Classroom experience

Students found many sources of air pollution in their surroundings. I told them that poisonous gases entering our lungs are absorbed into our blood. Dust and smoke stick inside our lungs and over the years our lungs get dirtier. Lungs of smokers and people living in polluted places get very dirty, lowering their ability to absorb oxygen.

The pictures on page 38 in the TextBook show:
1. Exhaust fumes from a car; 2. Wood-burning chulha; 3. Man smoking a cigarette and 4. Smoke stack of a factory.

Nos. 1. and 4. are situations where fossil fuels are probably being used. Fossil fuels, i.e. coal, petroleum and natural gas, are so named because they are found under the earth along with fossils of ancient plants and animals. Millions of years ago these plants and animals died, and their partly decomposed bodies were buried below many layers of earth. Under high temperature and pressure for millions of years, these layers were converted into coal, petroleum and natural gas - fuels which we use to produce heat, light and electricity. Petroleum is also used as a starting material to produce plastics, fertilizers, fabrics, and many things of our everyday use.

When fossil fuels burn they produce, besides carbon dioxide and water vapour, poisonous gases like carbon monoxide, hydrocarbons, sulphur oxides, nitrogen oxides and also particles of ash containing lead and other metals. Fossil fuels, being so widely used, are the most common sources of atmospheric pollution.

Apart from burning fuels, most manufacturing processes produce a number of other dangerous gases. Some of the common industries causing air pollution are, petroleum refineries, ore smelters, pulp and paper mills, iron and steel mills, organic and inorganic chemical factories (rubber, plastics, fertilizers, etc).

No. 2. (Chulhas) burn wood, straw or dung which are often the only fuels available to poor households in India. Estimately, more than three fourths of Indian housholds and more than half of the world's population rely on these fuels. They burn less efficiently than fossil fuels and so produce much larger amounts of smoke and ash particles. The women and small children who work or stay around these indoor chulhas are forced to breathe large amounts of dangerous gases and particles trapped in a small space, and so develop acute respiratory and eye infections. Continuous exposure often leads to permanent lung damage, cancer and heart disease. The long-term sickening effect of chulhas is exactly the same as that of heavy smoking.

Emissions from factories, vehicles and chulhas can be reduced considerably by using cleaner fuels, increasing the efficiency of burning and trapping the pollutants before they escape into the air. Improved designs of chulhas, engines, smoke stacks and exhaust pipes are now available. Though they might be expensive, the price is not too high to pay for our health.

No. 3. (Tobacco smoke) is the most avoidable form of air pollution. It contains, besides poisonous gases like carbon monoxide and hydrocarbons, particles of tar and other cancer-causing chemicals, and nicotine which is poisonous as well as addictive. Once you start smoking it is very difficult to stop. Cigarette smoke also contains thousands of other poisonous substances formed from burning of many chemicals used in manufacturing the cigarette. While some part of this highly dangerous mixture is breathed in by the smoker, most of it is breathed out. Thus, staying in an enclosed place with one or more smokers can be almost as bad as smoking cigarettes yourself! Children of smokers are prone to bronchitis, asthma and other respiratory diseases. Continuous exposure to heavy tobacco smoke can lead to lung damage, cancer and heart disease.

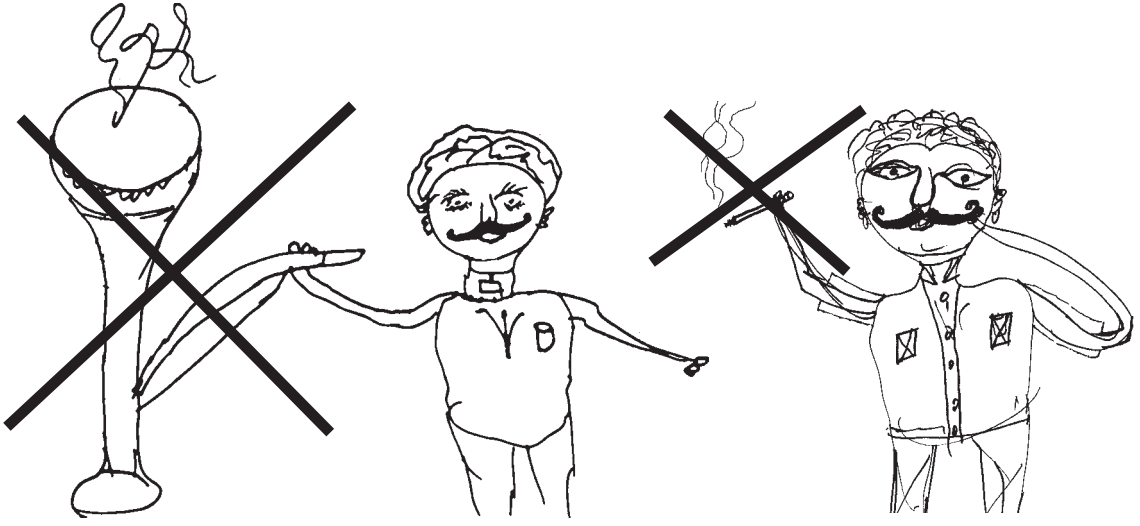
Take care!

Some poisonous gases have a smell, but others do not. Sometimes people can die from breathing too much of a poisonous gas that they cannot see or smell.

When tobacco burns it makes smoke that you can see as well as gases that you cannot see. The smoke and the gases are poisonous.

Breathing these gases may make you sick right away, or years later. Do not use tobacco or breathe tobacco smoke!

TOBACCO KILLS!



5. Air carries dust and smoke (2 periods + continuing observations TB p. 39)

a. Watch a beam of sunlight, or shine a bright light, in a darkened room. Describe what you see (Workbook page 67).

Students' observations

Dust particles and floating fibres were most visible close to the torch. They were constantly moving. Students recalled dust in a sunbeam, especially when the floor is being swept or the chalk-board dusted. They also remembered dust in the beam of a film projector.

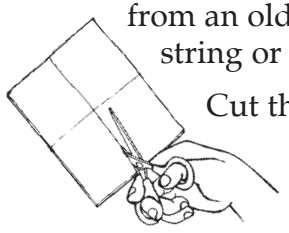
b. Sweep the floor of a room and collect the dust. Where did all this dust come from? Name some places and things that get very dirty or dusty. Think of how the dust came to these places.

Students' observations

Students brought the collected dust to the class. They noticed that, apart from particles of soil, it contained fibres from clothes and mats, small body parts of insects, etc. Students looked at the dust through a hand lens. I pointed out that dust from the floor contains a lot of coarse particles while dust from higher surfaces is finer: the latter contains only the very light particles that are easily carried by air. (There are even finer particles which never settle at all.)

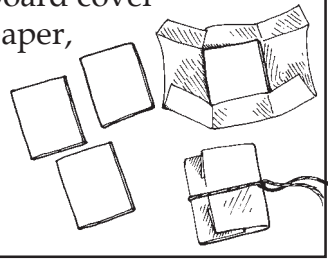
The dusty places named were, corners, high shelves and other undisturbed areas; verandah, floors and windowsills which get dust from outside; and fans which move through air collecting dust continuously.

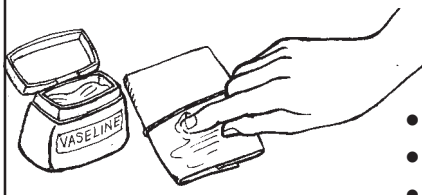
c. Find out how dusty the air is. You will need: cardboard cover from an old notebook, white cotton cloth or paper, string or clips.



Cut the cardboard into four pieces.

Cover each piece with white cotton cloth or paper.





Rub vaseline on the cloth or paper.

Hang these cards in four different places:

- a place that you think has very clean air,
- a place that you think has very dirty air
- any two other places.

Compare the cards after a few days. Describe what you see on them. Guess why the cards look the way they do (WorkBook page 67).

Can you use such cards to check how dirty the air is? Would this method work every time?

A hand lens makes things look bigger. Look at the dust and sand on your cards through a hand lens. Can you see any particles with the hand lens that you cannot see without it?

Students' observations

We hung the pieces of carboard rubbed with vaseline (1) inside the classroom, (2) near a road with heavy truck traffic, (3) on the terrace and (4) near the playground. After three days the piece near the road had large dark particles of soot and dust on it while the piece near the playground had smaller particles of reddish soil. The torn fibres on the edges of the cloth collected dust most effectively.

Students observations of the colours of dust, and of things seen in close examination of dust from different places, raised an interesting question, "What is dust made of?".

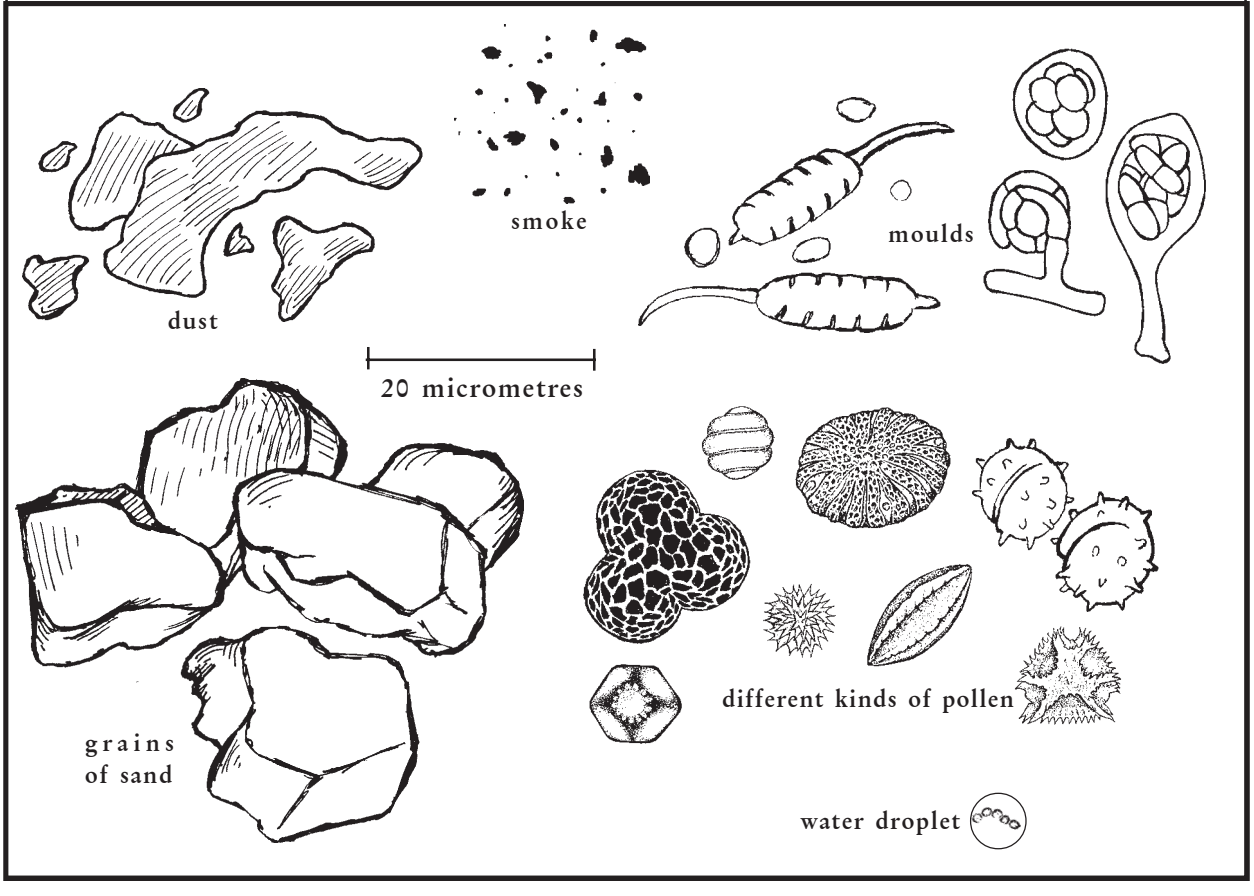
Roadside dust seemed to consist of soil and soot from vehicles. I told students that sand and soil are got from breaking down of rocks into tiny pieces. The picture on page 40 of the TextBook shows that these tiny pieces are even shaped like rocks! Other things floating in the air with dust are shown in the pictures on pages 40-41.

I used the hand lens to introduce two ideas: (i) the lens makes small things look bigger, and (ii) some tiny particles that may not be visible with the naked eye can be seen with the hand lens.

6. Air carries things that you cannot see (2 periods; TB p. 40, WB p. 67)

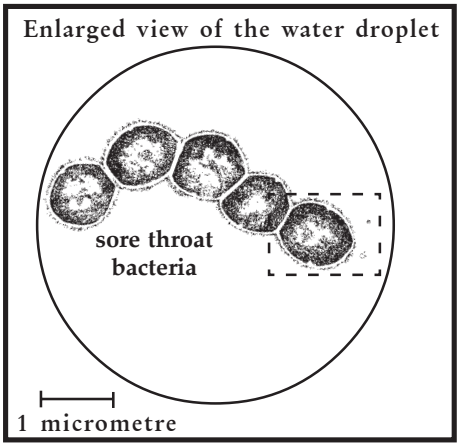
A microscope has many lenses in it. With a microscope you can see tiny things that you cannot see with a hand lens.

Some of the things floating in the air look like this through a microscope:



Which of these might be living things, or parts of living things? Check your guess with your teacher.

Tiny living things that you can see only through a microscope are called **microbes**.



The water droplet in this picture is much smaller than a raindrop. When you cough or sneeze you send thousands of water droplets into the air. You cannot see the smallest droplets except under a microscope.

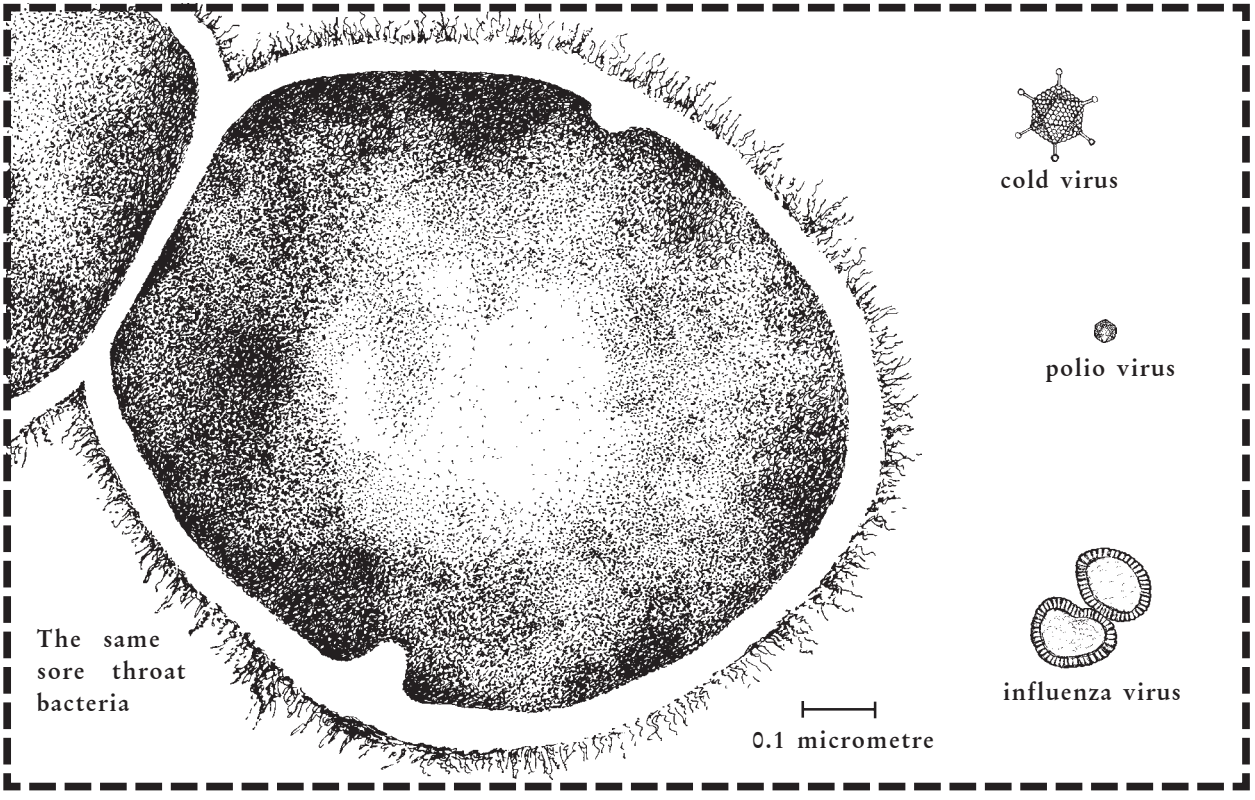
This close-up view of the water droplet shows it contains a chain of bacteria that can give you a sore throat. Can you see anything else in the dashed rectangle drawn in the droplet?

On the next page is a close-up view of that dashed rectangle. In it you see the sore throat bacteria and some viruses too.

Take care!

One sneeze or cough sends out tiny water droplets containing millions of microbes. Someone who breathes in these microbes might become sick. Cover your mouth and nose when you sneeze or cough!

There are many different kinds of moulds, bacteria, and viruses. Most of them are not harmful to people.



Classroom experiences

Students could imagine that an instrument with several lenses might make things look even bigger than a single lens does, enabling us to see things that cannot be seen with a hand lens. However they were somewhat mystified by the pictures in the TextBook. I told them that these were things too small to see with the naked eye, but large enough to see under a microscope. Such tiny particles of dust, water droplets, spores, pollen, bacteria and viruses can remain airborne for months or years (see explanation on pages96-98).

Many kinds of plants depend on the wind for pollination (carrying pollen to other plants).

One student asked if these things were as small as the molecules of gases shown (schematically) on page 35 of the TextBook. I explained that gas molecules are too small to see under the microscope (see below). Students then imagined many ways in which these particles could have got into the air.

> With very sharp eyesight we might discern an object about one tenth of a millimetre (100 micrometres) in size. Typically the grains of dust and sand that are suspended in the air are one-tenths of this size. Many microbes are even smaller. We measure their size in units much smaller than millimetres:
> 1 metre = 1000 millimetres
> 1 millimetre = 1000 micrometres
> 1 micrometre = 1000 nanometers
> Sizes of molecules are measured in Angstroms:
> 1 nanometer = 10 Angstroms
> The pictures on page 40 in the TextBook (p. 138 here) show things of the size of about 10 to 50 micrometres. In this picture a water droplet of roughly 5 micrometre diameter is shown. This water droplet might have come out with a sneeze or a cough. It contains a tiny chain of a kind of sore-throat bacteria. In the next picture, a part of this chain of bacteria is shown further magnified. Along with the bacteria some viruses are also shown. All these microbes could be carried inside such water droplets. The picture gives a relative idea of their sizes (see *Interesting questions* 8 and 9).
>
> All these things are blown or carried by the air. Millions of dead skin cells float off your body every day.
>
> Germs from a sick person are spread into the air by coughing, sneezing and spitting. When we cough or sneeze, a few cells burst open, releasing their contents as droplets containing bacteria or viruses. When spit dries, virus crystals are blown into the air. You can get these infections by breathing air containing these microbes.

Many kinds of disease-causing bacteria, viruses, spores and pollen are carried by the air. Examples are: bacteria which cause pneumonia, TB, diphtheria and leprosy, viruses of common cold, influenza, chickenpox, measles, mumps, conjunctivitis and poliomyelitis, and pollen or spores which cause allergies.

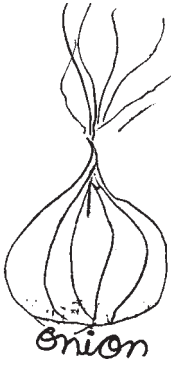
You should cover your mouth when you cough or sneeze because another person might catch the infection if they breathe in these microbes. Covering your mouth and nose with a handkerchief prevents most of the microbes from getting into the air.

Know these words

gas	water vapour	microscope	bacterium
nitrogen	poisonous gases	microbes	bacteria
oxygen	air pollution	mould	virus
carbon dioxide	decompose	pollen	viruses

Air that contains too much poisonous gas, smoke, dust or too many microbes is called **polluted air**.

EXERCISES (5 periods + homework to be done in parallel with classroom activities and discussion; WB p. 68)



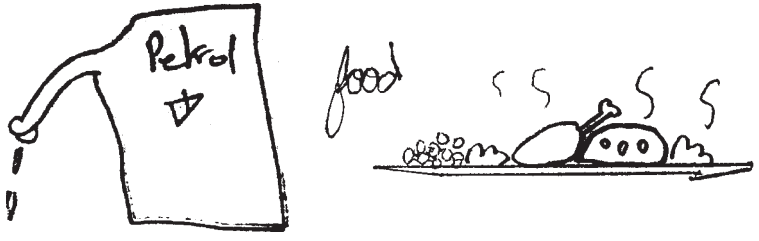
Name and Draw

1. Some things that smell bad

Students drew smoke from a fire, a garbage bin and open sewers (and one child drew a picture of a friend/enemy!).

2. Some things that smell good

Students made drawings of good-smelling flowers, grass, trees, perfume bottles, incense sticks (agarbatti), delicious foods etc. (Remember that good-smelling gases need not be safe!)



Interesting questions (WB p. 69)

1. You can blow out continuously for only a few seconds at a time. Why?

You can blow out only as much air as there is in the lungs (and not all of it, because the lungs, unlike a balloon, cannot collapse completely). Then you have to stop blowing to take in more air from outside. (See explanation for teachers on page 128.)

2. For which of these actions do you need to take deep breaths?

running, swimming, eating, shouting, writing, whistling, singing

Students thought deep breaths are needed for all of these except eating and writing. During the discussion they also mentioned other occasions for taking deep breaths. Some unusual and surprising responses were: after eating spicy food, when you are afraid, when the teacher gives a test and you don't know the answer, after concentrating on something for a long time, on smelling something nice, on yawning and before dying.

3. If you do not wipe things they get covered with dust. Why?

The particles of dust in the air slowly settle down.

4. Name some ways that dust gets into the air.

Dust is blown from dry places by the wind; vehicles and running animals kick up dust etc.

5. Name some ways that smoke and poisonous gases get into the air.

Examples had been discussed before.

6. Is there water in the air? How do you know?

Yes. Students had learnt about humidity in Chapter 1 (that it varies in different places, in the rainy season air feels damp, in winter it feels dry). In Chapter 5 they would learn more about water vapour.

7. Which of these gases can you smell?

nitrogen, oxygen, carbon dioxide, water vapour, kerosene vapour

Only kerosene vapour

8. From the pictures on pages 40-41 in the TextBook, guess which diseases spread through air?

Some diseases are listed on page 142. Though students may not know much about the diseases, from the pictures in the TextBook they might guess that cold, cough, influenza ('flu'), chicken pox and polio spread through the air. The dust, mould and pollen shown on page 40 might possibly cause allergies or asthma.

9. Arrange these microbes from largest to smallest:

sore throat bacterium, cold virus, mould, polio virus, influenza virus.

This question is meant to test the rather difficult idea of scale. Students need to combine the information from the two pictures on pages 40 and 41 in the TextBook (pages 138-140 here) to guess that mould is larger than the sore throat bacterium, which in turn is larger than the viruses.

The order is as follows:

mould, sore throat bacterium, influenza virus, cold virus, polio virus

What's the same? What's different? (WB p. 70)

1. What polluting things, for example, poisonous gases, dust, smoke or microbes, get into the air in the following ways?

Event	Poisonous gases	Dust	Smoke	Microbes
a. a bullock cart goes down a dusty road		✓		✓
b. a truck goes down a dusty road	✓	✓	✓	✓
c. a person spits				✓
d. a tree grows				

Students added that in the first three events oxygen was being removed from the air and carbon dioxide being added to it, while in the last event (tree growing) the opposite was happening. Trees also help to catch dust and smoke particles on their leaves, so removing them from the air.

2. Find the odd one out:
   a. air, water, food, sweets
   b. oxygen, carbon dioxide, water, water vapour
   c. gases, dust, smoke, rabbits, tiny living things

Some possible answers:

a. Sweets, because they are not necessary for life

b. Water, because it is not a gas

c. Rabbits, because they are not a part of air

Language-based exercises

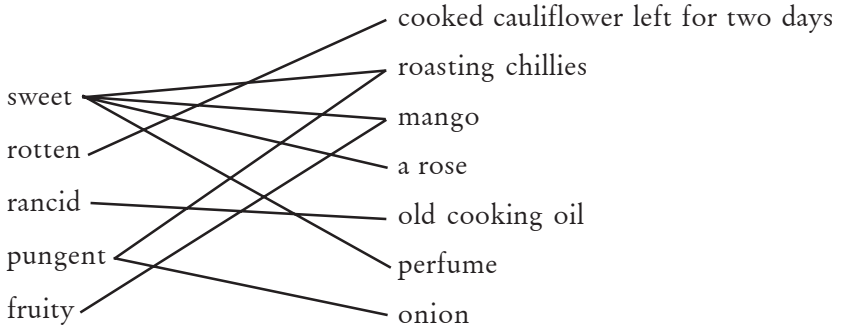
Talk and write

1. The air I breathe (Think of the air you breathe every day. Is it clean or dirty? Why do you think so? What things make your air either dirty or clean? What can you do to get clean air?)

Since students found the task a little difficult, I simplified it as follows - Where I found pollution; What I saw; What I smelt; What I thought; How we could stop this pollution.

Play with words (WB p. 71)

1. Find out what these smell words mean. Then match the smell words on the left with the things on the right.



Ask and find out

1. Have you seen waste materials being burnt? Why is waste burnt? Does burning waste cause any harm?

Students' observations

Since this question was taken up at the end of the Chapter, most students agreed that burning garbage pollutes the air. Some others said that smoke might drive out mosquitoes.

Burning is a quick way of disposing a large amount of waste, but it has many disadvantages. Burning produces smoke containing small unburnt particles, carbon dioxide, carbon monoxide and other harmful gases, depending on the type of waste being burnt. Urban household waste usually contains parts of processed goods like plastic, paper, rubber, plywood and synthetic or treated fabrics, which have been made by the addition of different chemicals. These chemicals produce highly toxic gases and poisonous soot.

Plant wastes are potentially a rich source of nutrients for the soil. By burning waste leaves and stems, most of these nutrients are destroyed. The mineral salts contained in dry ash easily flow away with the rain and so not do not enrich the soil. Plant wastes could be turned into manure by letting them decompose in a compost pit (see Chapter 10, pages 315-316, 320-321, 339-340).

2. Find out some ways in which poisonous gases get into the air.

Examples would depend on locality - outdoor pollution from thermal power plants, refineries, chemical plants, heavy diesel traffic or burning garbage; indoor pollution from chulhas or cigarette smoke.

3. Have you heard of people getting sick from gases and smoke?

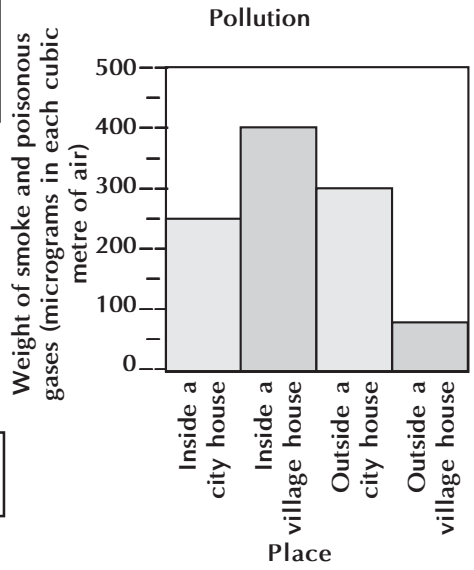
Many causes of respiratory diseases lie in the home or work environment but often they are not recognised. Living or working in places with chemical fumes, smoke, dust or fibres, leads to many sicknesses. Mineworkers, asbestos and cement workers inhale particles of corrosive dust. Textile workers could get sick from inhaling fibres. Many factories make or use chemicals which stay in the air making it harmful to breathe.

Quantitative thinking

Figure it out (WB p. 72)

1. Apu met a scientist who was measuring pollution. She showed him this graph of the amounts of pollution she had found in one city, and in a village some distance away.

a. What could be the reasons for pollution in each of the four places shown in the graph?



Sources of outdoor pollution can be guessed easily. In a city the most likely source of pollution is vehicle traffic, particularly using old and inefficient diesel or kerosene engines. The small amount of pollution shown in the village outdoors could be due to dust, pollen or decomposing matter. (See c. below for indoor pollution.)

b. Which place had the cleanest air? Can you explain why?

The cleanest air is shown in the graph to be in a village outdoor area, where there could be many trees and no vehicles or factories to cause major pollution.

c. Which was more polluted, the village home or the city home? Can you explain why that could be?

The graph shows the highest level of pollution to be inside the village house. This is likely to be the result of using wood or dung-burning chulhas without proper exhaust and ventilation arrangements.

Besides kerosene or wood fires for cooking or heating, there could be other sources of indoor air pollution like, tobacco smoke, accumulated dust, mould (fungus - particularly in damp houses), dust mites (tiny insects found in household dust), floating body parts of insects, cloth fibres and easily evaporating chemicals from paints and cleaning solutions. Excessive amounts of these might cause asthma and other breathing or eye problems.

Ask a question (WB p. 72)

Students' questions:

1. Why do wet leaves and wood produce more smoke when burnt than dry ones? (This question came up during the story; I answered it at the end of the Chapter)

Notice what other things produce smoke, and what are the things that do not produce smoke when burnt. Smoke consists of some gases along with unburnt or partially burnt particles of the material. These particles are produced when the material is incompletely burnt. The less complete the burning (as happens when the leaves or wood are wet), the more is the smoke produced.

2. How does air get into our body? Can air enter through the skin?

Air can enter the body only through openings like the nose and mouth, for example, while breathing, talking and eating. The oxygen in the air is carried by blood from the lungs to the rest of the body. Carbon dioxide is carried from all parts of the body back to the lungs from where it can leave the body. Air cannot enter through our skin. Many smaller animals do breathe through their skin.

DID YOU KNOW? (TB p. 44)

Holes in idli, dhokla, batura, bread and cake are made by carbon dioxide produced inside these foods.

Students' observations

Students' examples of foods with holes were much more varied than those given in the TextBook. They included: puri, idli, dosa, idli dough, dahi-vada, omlette, bread, mango shake, sour curd, fried or roasted papad and mysore pak. Some of these bubbles were made by ordinary air, some by water vapour and some by carbon dioxide.

> We make bubbles in omelette and milk shake by whipping to put air into them. Often bubbles are formed in foods when, in the process of cooking,

water in the food turns into water vapour. When water in some solid foods turns into water vapour it blows bubbles in the food. This happens in roasting phulka and papad and in frying pooris and other foods. Bubbles are also seen coming out through the oil.

Baking powder, which is added to cake batter, releases carbon dioxide on heating. On cooking the cake becomes firm, trapping the bubbles of carbon dioxide inside.

Bread, naan and batura are made by adding yeast to dough which is kept warm and moist. Yeast is actually a microscopic living thing which feeds on the dough and gives out carbon dioxide in respiration. This is called 'fermentation' of the dough. On baking, the yeast dies but the bubbles of carbon dioxide remain. Idli, dosai, dhokla, amboli and sour curd too are made by fermentation brought about by specific micro organisms. The gas in these bubbles is again carbon dioxide.

A very light gas called hydrogen is filled in the kind of balloons that rise high up in the air.

Most of the students had seen hydrogen balloons.

Toy balloons which float high in the air are sold at fairs and in public gardens. These balloons are usually filled with Hydrogen gas. Although this gas is highly inflammable and dangerous to handle in large quantity, it continues to be used.

One way in which the gas is produced is by mixing aluminium powder with caustic soda and water at the bottom of the gas cylinder. The caustic soda (sodium hydroxide) and water dissolve away the oxide coating on aluminium to form sodium aluminate. Once the oxide has gone, there is a chemical reaction of aluminium with water and caustic soda which produces hydrogen gas.

Helium, though twice as heavy as hydrogen, is a very light gas. It is safer to use since, unlike hydrogen, it does not react with air and explode. But helium is rare and very expensive so despite the dangers for people working with it, it is hydrogen that is filled in toy balloons in India. In Western countries helium is used instead.

Cooking gas cylinders contain a liquid called LPG (Liquified Petroleum Gas). When it comes out it is a gas. LPG is got from deep under the ground.

LPG stands for 'Liquid Petroleum Gas'. It is a constituent of natural gas, one of the fossil fuels discussed on page __. (In India LPG consists largely of butane gas while in some other countries it is propane gas.) When the gas is highly compressed it becomes a liquid which can be filled in cylinders and transported easily.

LPG burns in air. Though the products of burning (carbon dioxide and water vapour) are harmless, the gas itself is poisonous. The problem is that it has no smell. LPG factories add a little ethyl mercaptan (a liquid with a strong smell) to the LPG. That way people are warned if the LPG is leaking into the air.

SUPPLEMENTARY EXERCISES

Classroom discussion

1. When you ride on a bicycle or motorcycle you feel a wind. Does a person walking far from you on the road feel this wind? Why or why not? If a bus goes past you when you are walking on the road, you feel a wind. Does a person sitting in the bus feel the wind? Why or why not?

2. Find the names of some gases that can burn in air. (Cooking gas, gobar gas, biogas, hydrogen, burning effluents in an oil refinery)

UNIT 3

WATER

Chapter 5 Fun with water!
Chapter 6 Water and life
Chapter 7 Water and us

UNIT 3 Water

AN OVERVIEW

Objective **To experience everyday phenomena related with water and to understand the importance of water for life.**

3.1 To explore some phenomena related with water (water flows down, it can move things; other materials can float, sink or dissolve in water; water climbs up some materials, it evaporates and the vapour can condense)

3.2 To learn concepts and terminology related to properties of water (without formal definitions)

3.3 To understand that water is essential for life and therefore for us

3.4 To observe plants and animals living near water and to realise that life-forms are characteristic of habitats

3.5 To be aware of the fascinating variety of microscopic life-forms living in water

3.6 To relate some water-borne diseases with microbes carried by water

3.7 To know about and observe different sources of water

3.8 To record and quantify our personal usage of water

3.9 To understand ways in which water gets polluted and to realise that clean water is essential for good health

3.10 To know ways of getting safe drinking water

3.11 To realise that water is a precious resource and to find ways of conserving it

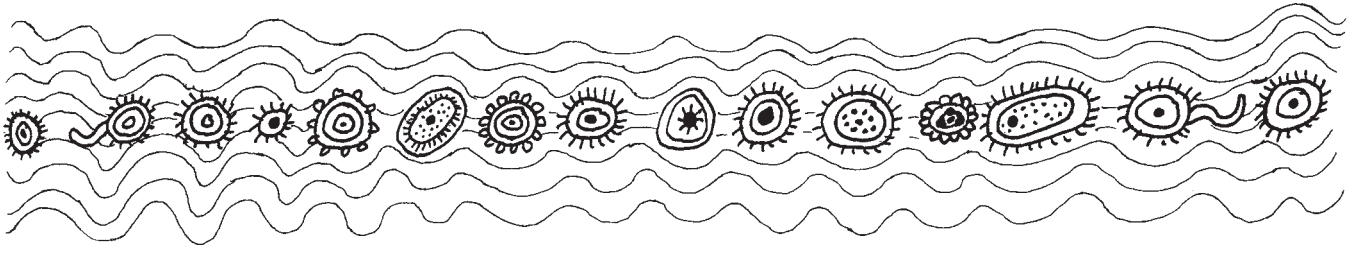
What is new in this Unit

Every child knows that we drink water when we feel thirsty. Through this Unit students should realise that water is essential for life itself. In Indian life and culture water holds a central place. Sources of water like wells and rivers and rain have important economic, cultural and social significance for us. The single most important factor affecting the Indian economy is the monsoon, and the subsequent management of rainwater. This Unit begins to introduce students to the critical role of water in our lives.

In later classes students will learn about the extraordinary physical and chemical properties of water which even make life possible; how water regulates the climate of the earth and hence cycles of birth, growth and reproduction; about the role of water in agriculture and industry; how the quality of water is degraded by human use and the necessity of conserving water resources. But in Class 4 we keep to the simplest of everyday experiences.

The Unit exposes students to common properties of liquids, and to some properties specific to water. The physical and biological aspects of water are dealt with in an integrated way. As in the previous Unit on Air, the experiences are given without much explanation. Though some explanations can be found in the Teacher's Book, their use is left to the teacher's discretion.

In 'Small Science' Class 3, students did some preparatory activities for measurement of volume and capacity. The volume units litre and millilitre were introduced in Class 3 mathematics. Now in Class 4 students apply these ideas to quantify their personal usage of water. There is reference to agriculture, but industrial usage, being somewhat removed from everyday experience, is not dealt with here. The Unit aims at social awareness and responsibility for conserving and sharing water resources.



Time-table P: Number of periods

Chapter 5		Chapter 6		Chapter 7	
P1-P14	- Activities	P29-P35	- Activities	P45-P60	- Activities
P15-P16	- Summary	P36	- Summary	P61-P72	- Exercises
P17-P28	- Exercises	P37-P44	- Exercises		

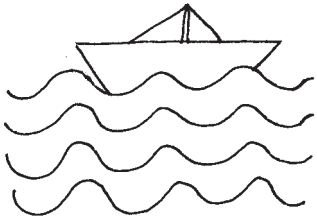
Some exercises are to be done along with activities and as home-work.

Materials and information to be collected for the Unit

Chapter 5: Ruler, tetrapacks (a large one between two students), scissors, glue, pencil; small containers for water, spoons, plates, small solid things like pieces of wood, cork, wax, metal, plastic, stone etc.; liquids like cooking oil, kerosene, milk, etc.; a few glasses and dishes, coloured cotton strings/handkerchief, cloth, ink, chalk, dry soil, blackboard/ slate, bottle of ice-cold drink, ice-cold water; two containers - one to fit inside the other, plastic sheet, stones, string, pan and lid, stove.

Chapter 6: Leaves, flowers, potted or other plant, cucumber or brinjal, salt, large clear plastic bag, thread; ruler, pencil, match boxes, cellotape, two similar flowers, glasses, dropper, ink, white flower, razor blade, mirror/ window pane/ piece of glass, plastic bag, string; water samples containing living things, hand lens.

Chapter 7: Information about water supply in the town or locality - sources of water and purification carried out; containers with capacity marked, one container to measure 1 litre, cellotape; glasses, water from at least two different places, soap powder, spoon, dish, cotton cloth.



CHAPTER 5

Fun with water!

ACTIVITIES

What water does (2 periods; TB p. 47, WB p. 75)

1. Water flows down

a. Put a few drops of water on one end of a ruler. Tilt the ruler. Watch the water flow. Do this several times. Try to make the water flow slower or faster.

Managing the classroom

These activities with water are simple to do, but the classroom management needs careful planning. Here is a sample lesson plan, prepared and tried out by Dr. Karen Haydock at Vivek High School, Chandigarh.

Ask the students to take out their pencils and scales, and open their TextBooks to page 52 and their WorkBooks to page 83. Ask how they could find out how water behaves on a flat or a sloping surface. Write some questions on the board, like:

Does a drop of water ever flow up a slope?
Can a drop of water stay still on a slope?
How can a flowing drop change directions?
Can you keep water in a drop, while the drop flows?
How can you make a drop flow faster?
How can you make a drop flow slower?

(Get the questions from the students. These questions are for stimulation and discussion. The students need not write the questions or the answers.)

Explain to the class that they are going to do an activity to find out. Ask what will happen if they spill a lot of water on their desks or on the floor. Show them a few cloths they can use to clean up any spills. Show them how they can pour a very small amount of water into a small cup or cap, and then use one finger to put a drop of water onto a scale, try to keep the drop from sliding off the scale, and see what happens when they carefully tilt the scale. Tell them that after they have finished experimenting, they should write down what they found in their workbooks, then empty any remaining water into a container at the front of the class.

Then tell the students to each try it for themselves, but they should stay at their desks unless they need to get a cloth. If a student has a question they should raise their hand. As the students are working, walk around the classroom to ask questions and give suggestions.

After the students have spent enough time, ask them to empty the water, clean up, and finish writing. Then get the class attention and discuss what happened.

Classroom experience

The activity was useful to demonstrate that water flowed on a downward slope and not on an upward one. But the speed of flow and variation of this with the slope was not so easy to see. Smoother rulers worked better.

b. Watch streams of water in a nullah or a river, near a public tap, a pump or a well. If it rains heavily, you see many streams.

Look at broad and narrow streams, slow and fast streams. Draw a stream of water showing the direction of flow (WorkBook page 75).

Students' observations

I had asked students to look around them for flowing water. They recalled these and also earlier instances: nallah, gutter, river, flood water (seen on TV news), mountain stream, fountain, rain, tap and a broken water pipe. Their examples of water that is not flowing: pond, well, puddle, tank, aquarium, swimming pool, water bottle, bucket, *matka* and *handi*.

Interesting responses: water in a gutter flows into a big gutter, which flows into the sea; sea water flows into the ocean. Most others said no, sea water does not flow; one student explained that waves from the sea move towards and away from the shore, but this water does not leave the sea.

The *Name and Draw* exercises 1. and 2. were done here.

> *Think! Think!*
>
> *Could you make a river flow in the opposite direction?*

Students' alternative conceptions

Holding up a student's picture of a stream flowing down a mountain I asked, "Why does the stream flow this way and not the other?" Students responded that the mountain was high and that water flows "from up to down." They had also seen this in the first Activity.

Thus, most students intuitively knew that water flows from a higher to a lower level as in a waterfall or a mountain stream or in the ruler activity. BUT this fact was not integrated with their daily observation of a stream on a plain, where the slope of the land is not obvious. This came out in a discussion on the *nullah* near their school. They knew that this *nullah* flowed from their school towards the Vashi creek and insisted that it never ever flowed the other way, that it would keep flowing the same way tomorrow, and next month and next year too.

When I asked what made them so sure, all sorts of 'justifications' were given: "It has dirty water", "The dirt clogs the nullah and does not let it flow backwards", "The nullah has to go to the sea", "It flows that way because of the wind...". Although they knew that the stream never reversed its direction, they tried to find other reasons for this. Only after some time one of the students said, "It depends on the land," and indicated a slope with his arm.

I asked students about the position of the tap in a bathroom or elsewhere and how the drain should be placed: the ground should slope towards the drain or else the water would go the wrong way. Some students knew that water tanks are built at a height. I felt that the intuitive explanation about water coming from a height was sufficient for now.

2. Water moves things (2 periods + homework; TB p. 47, WB p. 76)

a. Drop a leaf in a stream of water. Watch it flow down with the stream.

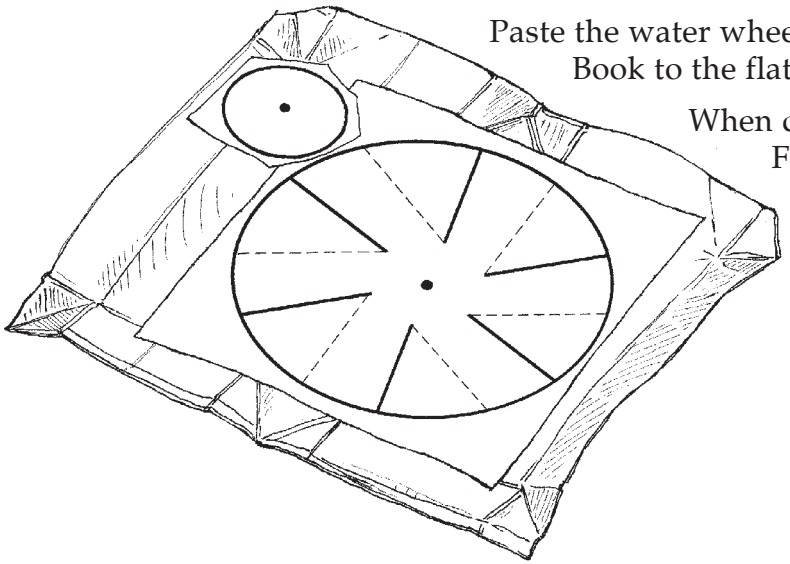
Students' observations

Students recalled instances when they had seen things moving with water (*Interesting question* 1). They noticed that usually slow streams flow smoothly while fast streams flow in a 'turbulent' way, and that obstacles create a region of turbulence.

Students also observed that monsoon streams carry a lot of mud. Flowing water carries away loose topsoil causing soil erosion. Any vegetation helps to prevent this erosion. See pages 170 and 234 for how plants help in conserving water.

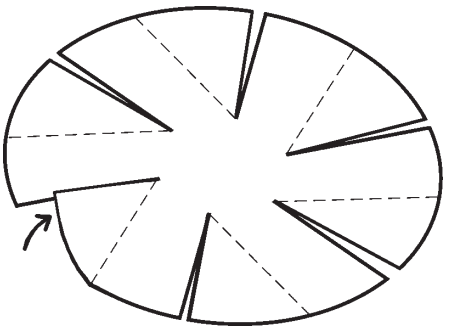
b. Make a water wheel:

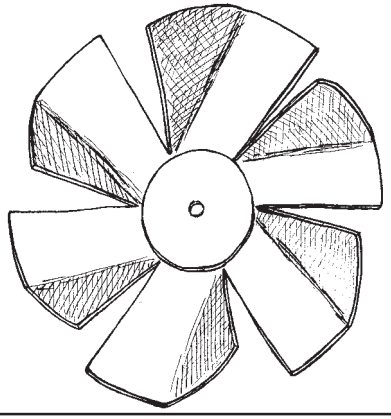
Cooking oil, milk and fruit drinks are sometimes sold in 'tetrapacks'. Open out one of these empty packets and wash it.



Paste the water wheel design on page 77 of your Work-Book to the flattened card.

When dry, cut along all the solid lines. Fold along all the dashed lines, as shown here.

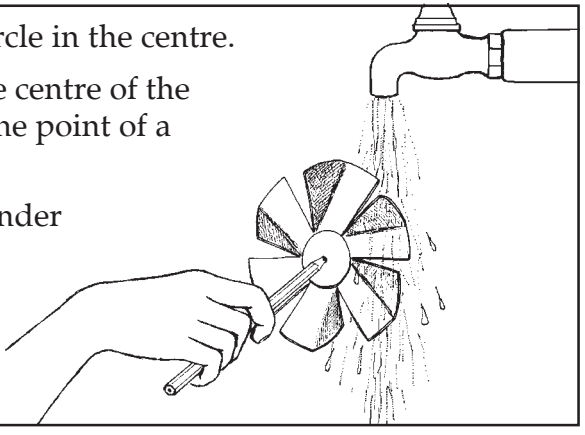




Paste the small circle in the centre.

Make a hole at the centre of the wheel and push the point of a pencil through it.

Hold the wheel under a stream of water from a tap.



Practical hints

For the water wheel we needed a material that was durable but easy to cut and bend. The tetrapack was the only one that we found suitable. Some weeks prior to doing the activity I asked students to start collecting used tetrapacks, though not to buy packages just for this. A few tetrapacks were collected. Students also tried cardboard, card paper coated with candle wax or crayons, laminated card from other packs etc., but these wheels got soaked after 2-3 rotations. This experimentation however helped develop students' understanding of some materials, their properties and possible uses. (Older students might use tin covers or waterproof cardboard with oil paint.)

Students worked in groups, helping each other. A few made the mistake of cutting along the dotted lines so had to re-do their work. They tried the wheels in water during the break or at home.

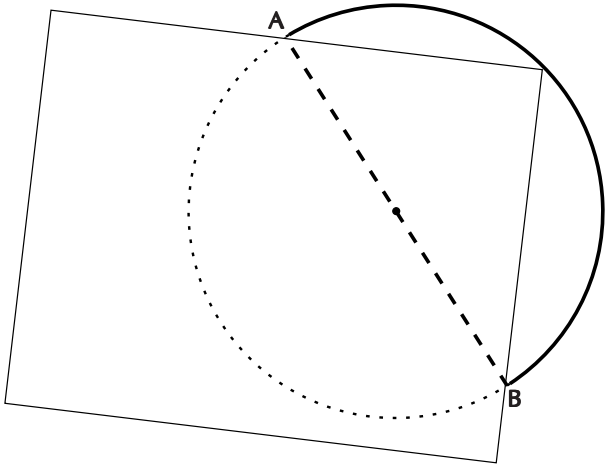
> The tetrapack material is made of six layers: an inner layer of polyethylene which seals in the liquid; a polythene adhesive layer for strength; aluminium foil to keep out light, odours and oxygen; a polythene adhesive layer again; paper board for rigidity and strength; and a final outside polythene layer to keep out moisture and other contaminants.

The layers are sealed together by heat, resulting in a strong, durable material. The layer of paper being tightly sealed between layers of polythene, does not get wet. The material is safe and convenient for storing food, but after use its durability becomes a disadvantage as the discarded containers do not degrade easily while also leaching toxins into the soil.

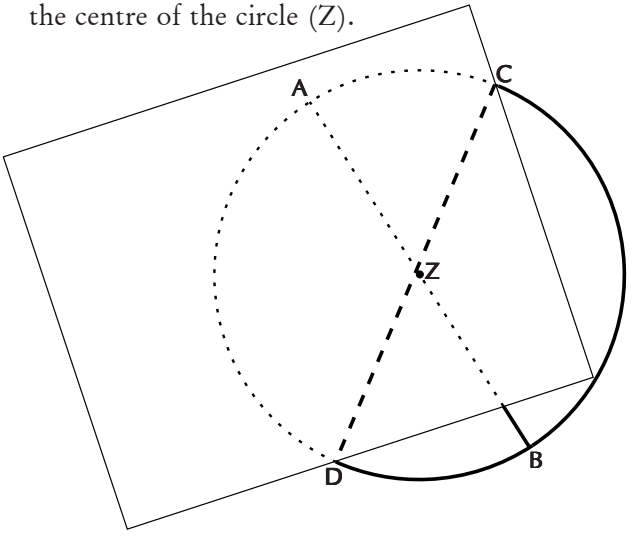
Practical hints

The wheel shape might be drawn using a ruler and compass but students of Class 4 are normally not familiar with the use of a compass. Another way is to use a circular lid and a rectangular piece of paper. Trace around the lid to make a circle. In order to divide the circle into sixths, you need to find the centre of the circle.

(1) Place a corner of the paper anywhere on the circle and mark the two points (A and B) where the edges of the paper intersect the circle. Draw a straight line between A and B. This line passes through the centre of the circle.

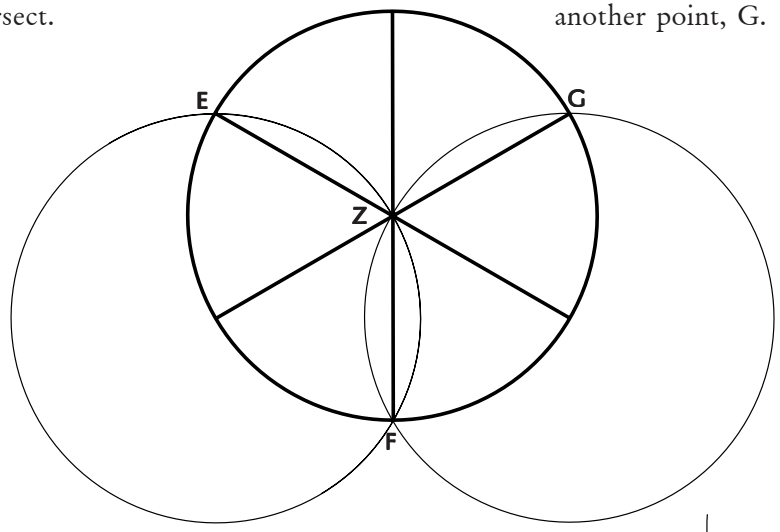


(2) Find another line that passes through the centre by placing the corner of paper at another position and drawing a line between the points C and D. The two lines AB and CD will intersect at the centre of the circle (Z).

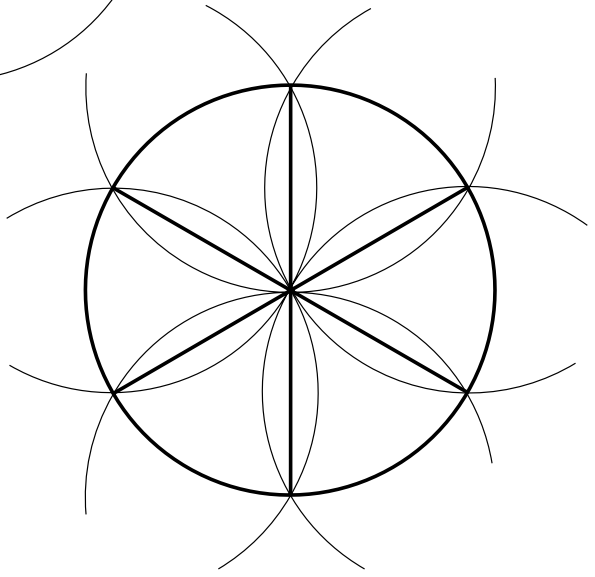


(3) Use the lid to make another circle that passes through Z. Mark points E and F where these two circles intersect.

(4) Use the lid to make a third circle that passes through Z and F, and intersects the first circle at another point, G.



(5) By extending the lines ZE, ZF, and ZG, you will have divided the circle into six equal parts.



3. Float, sink or mix? (2 periods + homework for Activities 3 and 4; TB p. 48)

a. Take some water in several containers. Find different small solids like, pieces of wood, cork, wax, metal, plastic, stones, leaves, seeds, lump of mud, sand, jaggery, butter, salt ...

Make a guess: will it **float**, **sink** or **mix** in water?

One by one, put the things in the water. Stir the mixture and wait for some time. Find out if your guesses (**float**, **sink** or **mix**) were right.

Did some things first float and then sink? Why?

Watch the floating things carefully. How much of the thing is above and how much below the surface of water? Is it lying straight or tilted? Draw a picture of how it looks in the WorkBook, page 76.

Classroom experience

I called two students at a time to do each step of the activity. I got some things made from almost a single material, like, a block of wood, a piece of cotton wool, an eraser, a pin, an iron nail, a plastic ruler, an aluminium strip and paraffin wax from a candle. Such objects helped to get across the idea of 'material' as different from 'thing'. Some food materials were also used.

In most cases students correctly predicted "float, sink or mix", but there were surprises. For example, they were sure that wax and butter would both sink and were surprised when they floated. They were also surprised that the size of the object did not matter, only the material did.

The drawing exercise helped students to observe closely, to see that things floated with the heavier end down, and that the fraction submerged differed among objects (it would depend on the density of the material).

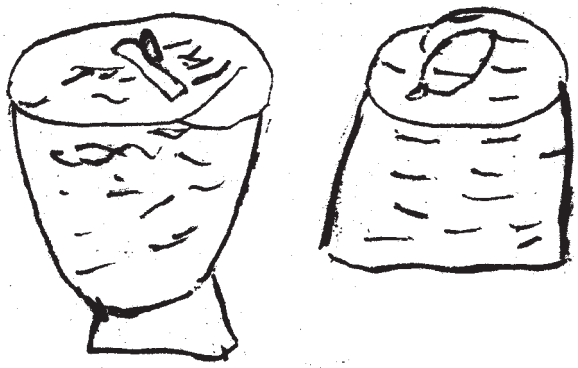
Observation and interpretation

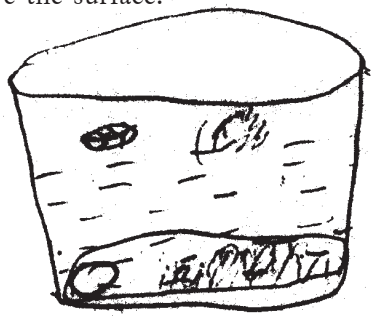
I wanted to teach students to report their observations - I expected that they would be able to say, "the piece of wood floated." In English, Hindi as well as Marathi I found that students had trouble departing from the present perfect tense, as in "A piece of wood

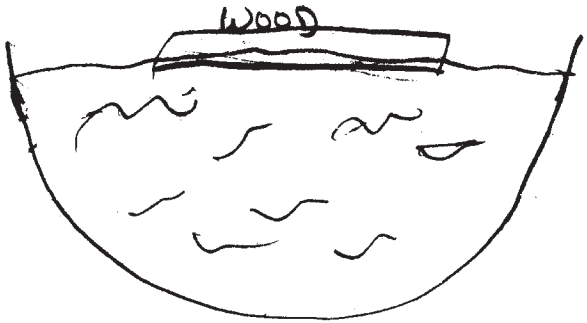
floats." Traditionally teachers too prefer words like `floats' (a generalisation) to `floated' (an observation). A generalisation based on a single experience is certainly invalid. In this case the conclusion `wood floats' is not too wrong for everyday purpose (though a few kinds of wood do sink in water - see *What's the same? What's different?* p.188). Subsequent to all the discussion, students did arrive at some generalisations (eg. *Interesting question* 3.). But in the activities I insisted on recording observation and discouraged uncritical generalisation.

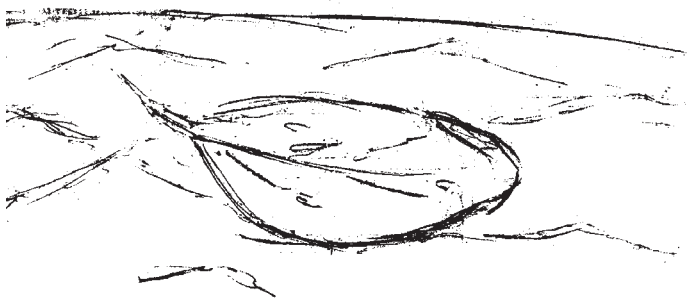
Some things floating on water

Students should be encouraged to notice and draw the orientation of each object on the water, and whether part is emerging above the surface.









b. Now add these different liquids to the water: cooking oil, kerosene, milk, machine oil, water paint, oil paint, liquid soap, honey, etc.

First guess whether the liquids will float, sink or mix in water. Then try it out.

Keep aside the solids and liquids that mixed in water. You need them for the next activity.

Classroom experience

An unexpected bonus from this Activity was that students got familiarised with many liquids of which earlier they knew only the names (eg. kerosene, spirit, machine oil). Most had probably never handled, smelled or wondered about liquids other than water. An example: they were fascinated by the motion of honey through water - "it looks like a water plant."

Liquids which do not mix in water will sink if their density is more than water and float if their density is less than water. (See p.190 for densities of some liquids.)

Think! Think!

Could you make a stone float on water? How?

Could you make an air-balloon sink in water? How?

At first some students imagined that though a large stone would sink in water, a small one might float - they even tried it out. It would be hard to carve a stone into a hollow shape that could float - easier would be to stick a small stone to a blown-up balloon, or to keep the stone inside a floating boat (eg. a paper boat). A heavy-enough stone tied to a blown balloon would make it sink in water.

4. Water dissolves things (1 period for writing and discussion; TB p. 49)

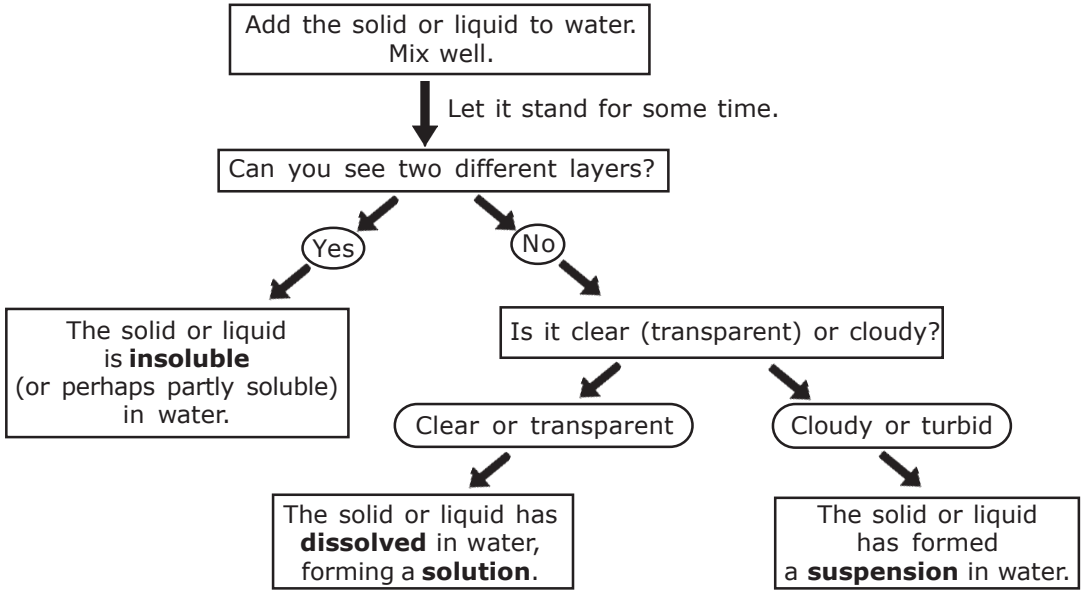
You have found that some things mix in water. Stir these mixtures. Observe what happens (WorkBook page 80).

When you stopped stirring, did the solid or liquid remain mixed in the water? Or did it get separated from the water?

Is the mixture clear or turbid? If the mixture is clear, the solid or liquid has **dissolved** in water. The clear mixture is called a **solution**.

Pour some of the solutions into small plates. Keep the plates in the sun till they dry.

Is anything left in the plates?



Preparation for the activity

Possible materials for this activity are:

i. Soluble in water: salt, sugar, syrup, honey, spirit, alcohol, liquid soap ...

ii. Suspensions in water: mud, clay, soap, phenyl cleaner, water colour, flour, milk, fruit juice ...

iii. Insoluble in water: stone, sand, rubber, glass, plastic, steel, iron, wax, grease, oil, kerosene ...

Students' observations

Students noticed that as grains of sugar dissolve in water they become smaller and smaller till they disappear completely. A drop of ink spreads out slowly in water. The words 'clear' and 'turbid / cloudy' could only be understood through observation. I explained that a 'clear' mixture might also be coloured (eg. a solution of honey, jaggery, or soluble ink). One student remembered the Hindi song, "*Pani re pani thera rang kaisa, rang milaau uske jaisa.*" We recovered some of the solutes as residue after evaporation.

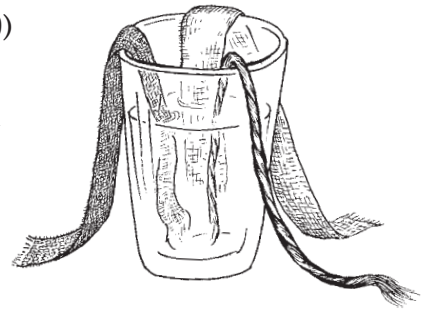
The ability of water to dissolve many things along with its tendency to stick to most materials (seen in the next activity) makes it a good cleaning agent. See also *Classroom discussion* 3., page 187.

> Many gases too dissolve in water. Natural water usually has some dissolved air - at 20 deg.C and normal atmospheric pressure about 15 ml. of air dissolves in 1 l. of water. Under high pressure more air dissolves. When water rushes out from a pipe where it has been under high pressure, it can no more support so much dissolved air and minute air bubbles are formed making the water look cloudy. For other examples see *Interesting question 4*., page 184. I asked students to compare the tastes of filtered drinking water and the same water after boiling and cooling. The difference in taste is due to some dissolved gases having escaped from the water when it is boiled.

5. Water climbs (2 periods; TB p. 49, WB p. 80)

a. Take water in a glass. Dip one end of a coloured cotton string, or the corner of a coloured handkerchief, in the water. Watch after about half an hour.

Touch the part of the string or handkerchief that is outside the water. Is it wet? How did it get wet? Make your guess.



Classroom experience

Students brought a variety of handkerchiefs, mostly cotton, some polyester and silk. In cotton there were varieties like flannel, turkish cloth and casement. Cotton cloth absorbed faster and more water than synthetic and jute; turkish towel was the best absorber getting completely soaked in an hour when the water was only part of the way up the other types of cloth. We concluded that the kind of material and probably also the type of weave made a difference to the rate of absorption.

Water wets most surfaces. This wetting happens because usually the attractive force between molecules of water and molecules of the surface (adhesion) is larger than the force between the water molecules (cohesion). The result of the wetting is that water climbs up the walls of the container. In a narrow container (a thin tube - also called a 'capillary'), the liquid climbs higher. (If the cohesive force is larger than the adhesive force - as with mercury in glass or water in an oily container, then the liquid is depressed in the container.)

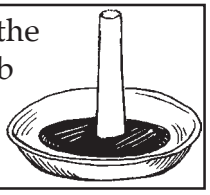
Each cotton fibre is actually a long, thin, tube-shaped cell made of spirally arranged cellulose molecules. Water climbs up the cellulose capillaries and wets the rest of the cloth or paper. Vertical capillary action in the cloth is limited by gravity while in the horizontal direction it is limited by evaporation: if evaporation is faster than the capillarity rate, then the flow will stop.

Students' observations

Students' examples of liquids climbing included a sponge, thread, cardboard, brick, unglazed clay vessel, a wall in the monsoon, a drop of ink sucked by a fountain pen, tea climbing up bread or biscuit, etc.. They pointed out that a biscuit swells when it absorbs water, and so does a wall. Some other observations:

A thick cotton thread absorbs water quite fast, making it drip out at the other end of the thread. Water goes further along a horizontally placed thread or cloth than a vertically placed one. If you drop a piece of crumpled tissue paper in water, the water climbs up to the parts above the water. When these parts of the paper get wet and heavy, the paper sinks. If you throw crumpled cloth rather than paper, the cloth spreads out on the water before it sinks.

b. Pour some ink in a plate. Keep a stick of chalk standing in the plate (WorkBook page 81). Do you think that the ink will climb the chalk? Guess how long it will take for the ink to climb 1, 2, 3 or 4 cm up the stick of chalk. Do it and see.



Classroom experience

The students counted 180 sec for the water to reach the 4 cm mark on the chalk.

c. In a glass pour some water up to a height of 2-3 cm. Add dry soil to fill the glass. Watch the water climb up through the mud. In this way water that is deep in the soil can reach the roots of plants.

Classroom experience

Since the soil was a little moist we dried it in the sun for a day. On putting it in the glass, the water at the bottom started climbing up and in twenty minutes the top of the soil was wet.

> The distribution of water in soil depends largely on capillary action. The spaces between soil particles form a network of capillary tubes of roughly triangular cross-section. The tubes are thinner in fine or tightly packed soils like clay, causing water from the lower layers to rise to the top and evaporate. Plants loosen the soil, preventing this evaporation.

6. Liquid water turns into water vapour (1 period + daily observations)

Watch water **evaporate (TB p. 50, WB p. 81)**.

a. Wipe a blackboard or a slate with a wet cloth. When a part of the board is dry, spread out the remaining water with your finger. Describe how the water evaporated. Where did it go?

Classroom experience

Though the experience of drying was common, students could not at once say where the water had gone. I asked them to give other instances where water disappears. Their examples included clothes drying, hair drying after a bath, drying of washed grains, washed plates and of cooking vegetables. Where did this water go? (See responses under *Think Think*.) Here I introduced the words 'evaporates' and 'evaporation'.

When spread out the water dried faster (increased surface area speeded up evaporation). Students also noticed that the drying started at the edges of the patches, where probably the film of water was thinner; also that drying was speeded up by holding the slate in a breeze or by moving it to and fro.

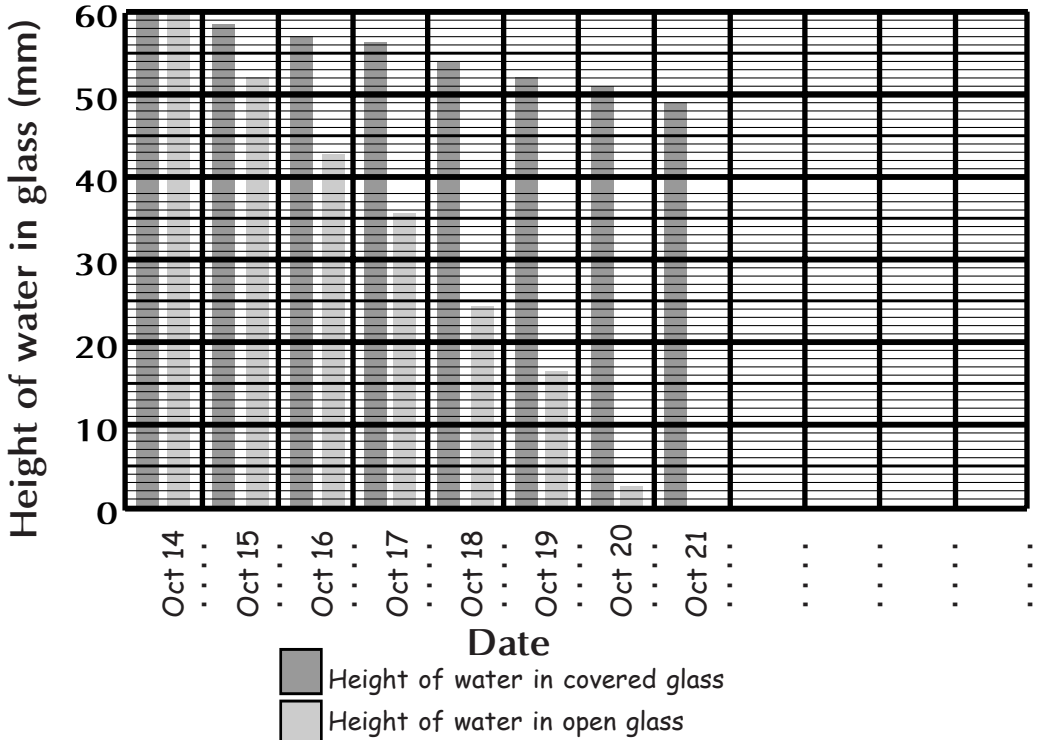
b. Fill two identical glasses with water up to 60 mm (6 cm). Stick a strip of paper on the outside of both glasses. Mark the level of water on the two strips.

Keep one glass covered and the other open. Every day mark the level of water on the two strips. Note the measurement in the Table in your Work-Book on page 81. Draw a graph.

Classroom experience

Every day the level of water in the uncovered glass went down by a few millimetres. Contrary to our expectations, the level of water in the covered glass also fell, though much slower. In eight days the uncovered glass was dry while the covered one was down more than a centimetre. Students guessed that water vapour from the covered glass could not escape or did so very slowly. Perhaps some intuitive idea of vapour saturation came up here but I did not pursue it.

Sample graph (open and covered glasses marked with different colours)



7. Water vapour turns into liquid water (2 periods; TB p. 50, WB p. 82)

Watch water vapour **condense**.

a. Touch a bottle of ice-cold drink. Check if it is wet on the outside. Wipe the bottle and, after a few seconds, touch it again.

Is the bottle wet again? Is this water coloured or sweet like the cold drink? Where did the water come from? Why do you think so?

Observation and interpretation

Students noticed that the bottle of cold drink got wet on the outside. A few minutes after they wiped the water off, the bottle was wet again! They could not answer where this water came from. Most of the students said, "(it is wet) because it is cold." They also gave other instances, like kulfi cones and ice cream cups getting wet on the outside. Some thought that the water might come from the kulfi. Others disagreed. I asked students to give reasons for their guesses. Their arguments:

"The water outside is not sticky like the cold drink."

"There are no holes in the ice-cream cup; it does not leak."

"If there is warm water in the bottle it does not come out. Why should cold water come out?"

Although some students were able to justify their reasoning in this way, there were a few students who thought perhaps the water might be coloured like the cold drink and sweet too. Later in the discussion they agreed with the majority view. I told them that when the water vapour in the air touched the glass it became cold and thus turned into water.

Linkage across topics

There was some discussion about where the water vapour in the room might have come from. Some said it came from 'the atmosphere'. When I asked them to be more specific, they suggested - evaporation from the sea; water evaporated from the blackboard in the previous experiment might still be there in the room; water vapour might have come from our breath.

"Can you **feel** water vapour in the air?", I asked, and then recalled the discussion on humidity (Activity 8 in Chapter 1). Some students realised that `humidity' was the amount of water vapour in the air.

Then I introduced the words 'condenses' and 'condensation', as the opposites of 'evaporates' and 'evaporation'.

b. Take two glasses. Tightly wrap a thick dry cloth around one glass. Pour ice-cold water into both glasses. Guess: will both the glasses be wet? After a minute touch the glasses from outside.

Are both glasses wet? Is the cloth wet? Now do you think the water came from inside the glass or from outside? Why do you think so? (WorkBook page 82)

Observation and interpretation

I asked students to predict the outcome of the experiment. They said unanimously that both glasses would become wet from the outside, and that the cloth would be wet where it touched the glass. When the cloth remained dry, they were surprised. I asked them to explain what had happened. The responses: "The cloth was very tightly wrapped"; "The cloth has no holes so the water could not come out."

Apparently when asked to interpret this unexpected result students had gone back to their first erroneous intuitive idea that the water came from inside the glass and not from outside. After four months of working with these new concepts I felt they were still having trouble imagining air / gases / water vapour as material substances.

We went slowly through the steps of the argument:

Why does the glass become wet? (Water vapour touches the cold glass and turns to water) Where is the water vapour? (Outside the glass) Can the water vapour reach / touch the glass through the cloth? If it does not reach the glass can it become cold? If it does not become cold will it turn to water and so stick around the glass? If there is not enough water on the glass will the cloth become wet?

A missing piece of the argument was the low thermal conductivity of the cloth. The air outside the glass could not get cold enough for the water vapour to condense even on the outside of the cloth (the students all expected the inner surface of the cloth to get wet first). Since the discussion was already getting a little heavy for many students, I did not think it appropriate to enter into such detail. The experiment illustrated to me that a seemingly simple argument can have so many steps to it. Understanding becomes especially difficult if, as in the present case, the conclusion goes against our intuition.

8. Water to vapour (and back to water)! (2 periods; TB p. 51)

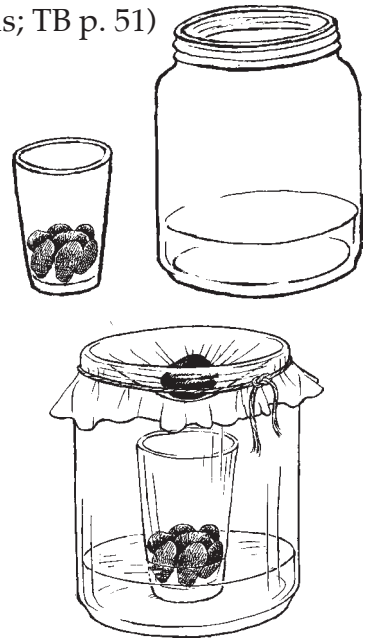
a. Take two containers, one a little smaller than the other.

Pour some water in the large container. In the smaller container put only a few dry stones. Keep the small container inside the larger one.

Tie a dry plastic sheet over the mouth of the larger container. A stone at the centre of the sheet should make it slope into the smaller container.

Keep the containers out in the sun. Open them at the end of the day.

Is the plastic sheet still dry? Are the stones in the inner container still dry? Guess why this might have happened (WorkBook page 83).

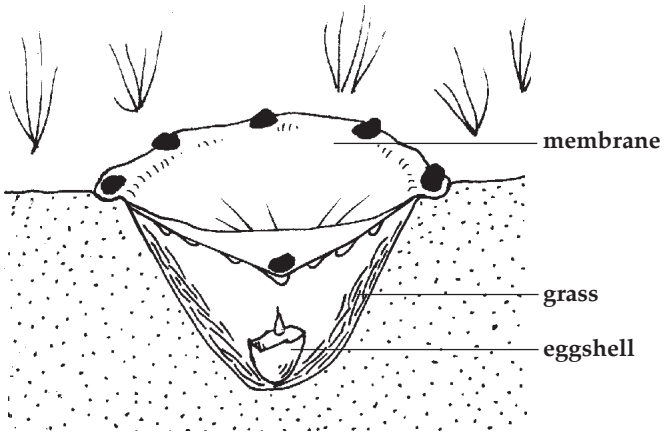


Students' observations

On a hot dry day we found that, with the containers kept outdoors for three hours, the stones in the inner container were quite wet. By the next day more water was collected. On humid days (in the rainy season) there was no water collected even after two days, perhaps because the evaporation was slow.

Observation and interpretation

Some of the students could not immediately understand how water collected in the inner container. On questioning I found that they expected water vapour to pass out through the plastic cover, while some thought that water might pass magically from the outer to the inner container. After clarifying these points I felt that, on the whole, the demonstration made 'evaporation' and 'condensation' more real to students.



This technique is used by the Basarva tribe of the Kalahari desert in South-Central Africa to obtain drinking water out of water vapour given out by plants. They dig a depression in the sand and lay grasses in it with half of an ostrich eggshell in the centre to hold the collected water. Then they cover the depression with a transparent animal membrane (usually a bladder) which slopes into the eggshell. During the day sunlight passes through the transparent membrane speeding up evaporation and transpiration. At night the cold desert air cools the skin making water condense into the ostrich eggshell.

The process of converting a liquid into vapour and then condensing it back to liquid is called 'distillation'. Normally heat is used to speed up the evaporation, and 'distilled water' is therefore expensive, but the Basarva method makes use of the free heat of the sun. The method can also be used to convert muddy or impure water into pure drinking water.

b. Boil water with the help of an older person. Hold a cold lid above the boiling water. Where did the water on the lid come from?

Is there now more, less or the same amount of water in the vessel? (Work-Book page 83)

Classroom experience

Students had seen water condensed on the lid of cooking pots. They could now state that water had 'evaporated' from the boiling pot and then 'condensed' on the lid. (Some called these drops 'bubbles', but others argued against this.) I reminded students that water vapour is invisible. Steam contains tiny water drops so it is visible - like clouds. To find out if there was less water in the vessel than before, students suggested putting a mark on the vessel and checking if the level went down.

When we heat water in a pot we first see very small bubbles rising in it. These are bubbles of air that was dissolved in the cold water. When water gets hot it cannot hold the dissolved air, which then forms bubbles. When the water is heated further, bubbles of water vapour are formed. Before the water is hot enough to boil, the vapour in these bubbles is at a lower pressure compared to the pressure outside. These early bubbles collapse and the vapour in them condenses back to water. The boiling point is the temperature at which the pressure of vapour inside the bubbles becomes equal to the atmospheric pressure. Now the bubbles do not get crushed - they rise to the surface and burst there. The boiling point of water at atmospheric pressure is 100°C.

Think! Think!

When water turns into vapour, where does it go?

Students' alternative conceptions

Students knew that evaporated water forms clouds. However many were under the impression that all the water which evaporates anywhere goes directly to the sky and forms clouds. I recalled the observations on humidity (Chapter 1) and discussion on water molecules (vapour) and water droplets in the air (Chapter 4). In Chapter 6 again students would learn about water vapour given out by plants. All these experiences should help them realise that water and water vapour are all around us, not just high up in the clouds.

When a huge ocean is heated by the sun, about 10,000,000,000,000,000 litres of water turns into vapour. What would happen if this vapour became cold and turned back into water?

A rough estimate of the amount of water evaporating from the oceans every year is 5×10^{16} litres. Most of this water falls back into the sea as rain or snow. About one tenth of it blows towards land and falls there - like our monsoon

rain. Taking the earth as a whole, much of the rain that falls on land is made of water that has evaporated from the land or been taken up by plants and given back to the atmosphere.

The water cycle (2 periods; TB p. 52)

Describe the journey of the water molecule in the picture on the next page (Workbook page 84).

Write a story about what happens to this water molecule after number 22, shown in the picture.

In which places was the water molecule a part of vapour?

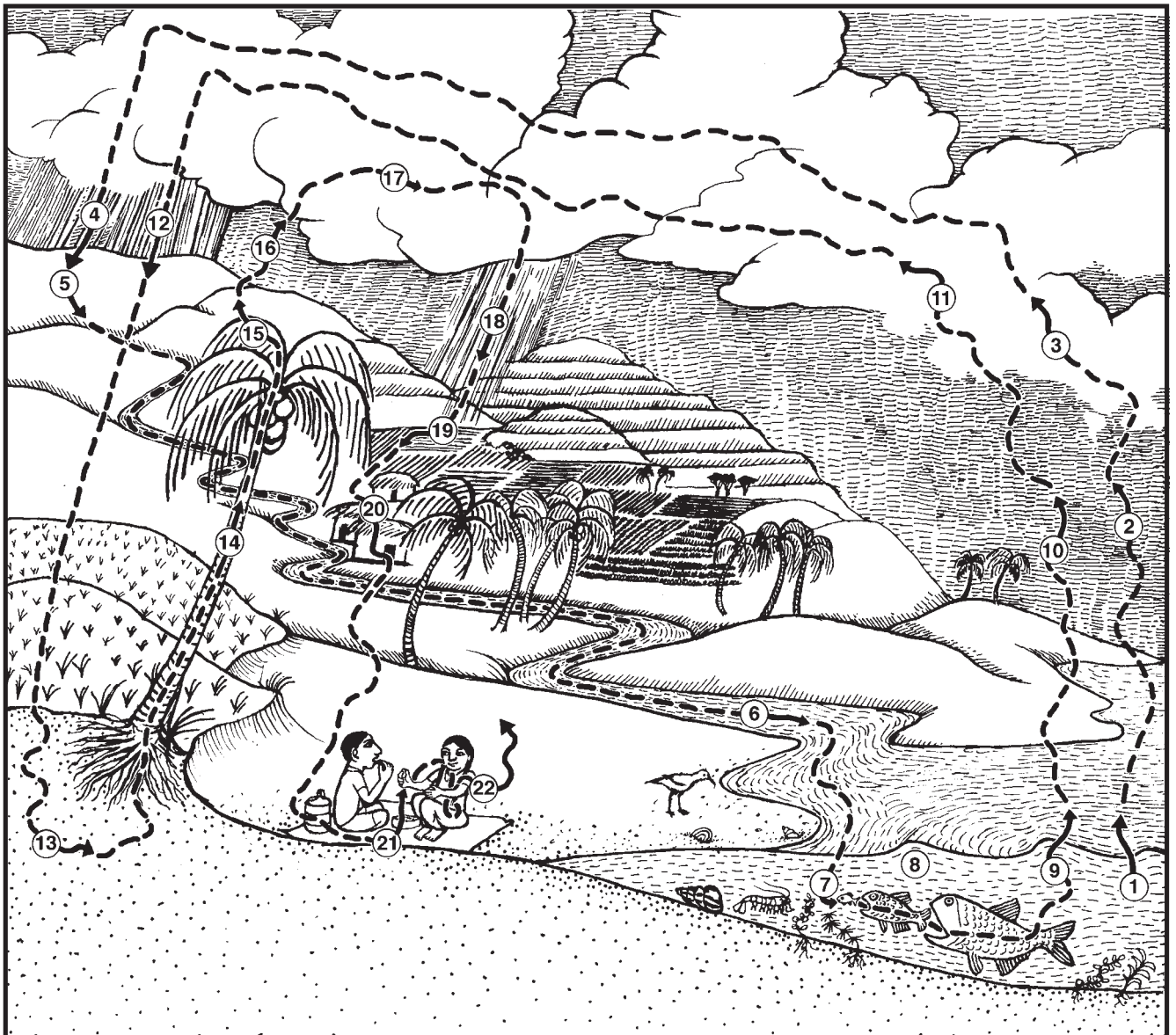
In which places was the water molecule a part of liquid?

Classroom experience

The picture of the water cycle and the accompanying story (given below) have been done by Karen. I read out the story. The students enjoyed hearing it and most of them were excited to then continue the story in their WorkBooks. I felt that the activities on vaporisation, condensation and rain followed by this story helped students understand the cycle better. Later they did the *Show and tell* exercise.

A Story That Goes Round And Round In A Cycle

Once upon a time there was a molecule of water jostling around in the ocean, "Jostle jostle jostle." (1). It evaporated and rose up in the air, "Ooper ooper ooooper" (2)- joining with other water molecules to make clouds (3). The wind blew the clouds up high over the hills, "Hhawa hhawaa hhaawaa" - where the water molecules got so cold, "Brraarrararra" - that they got together to form drops of water that fell as rain, "Patrrng! Pattappatttapap!"(4). The water molecule sank down into the earth and seeped through the soil, "Underunderunder" (5). Then the water molecule joined up with other water moleules and so many other water molecules and flowed down the winding river, "Flow ah fl ow ah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ow ah" (6). It flowed all the way down into the nice warm ocean again, "Jostle jostle - Gulp!" (7). A fish drank the water molecule (8)! But that fish was eaten by another fish and that fish was eaten by another fish and that fish - died! "Deadeadeadead." So the water molecule went back into the ocean, "Jostle jostle jostle" (9) - and then it evaporated again and rose up high in the air, "Ooper ooper ooooper!" (10). Now it was part of a cloud again with the wind blowing "Hhawa hhawaa hhaawaa"(11), and the water molecules getting cold - "Brraarrararra!" So they formed drops of water that fell as rain, "Pattattarrng! Pattappatttappap!"(12) The water molecule sank down into the earth and seeped through the soil, "Underunderunderr" (13). Then the water molecule went into a tiny root and was carried into a larger root and into a tree trunk (14) and into a leaf (15) - where it escaped being eaten up by the leaf, and instead evaporated and rose up in the air, "Ooper ooper OOOOper" (16) - joining with other water molecules to make clouds (17). The clouds rose, and down came the water molecule in a drop of rain, "ttaptapapta ptattappatttpapap!" (18). This time the water molecule went into a paddy field (19), and got stuck inside a grain of rice. Even when the rice was dried out, this water molecule was one of the few that did not evaporate. It stayed right inside that grain of rice until - it was boiled and bubbled, "Bbublebububleublbubollobub" (20) - and prepared for a tiffen lunch. A child ate that grain of rice, "Khao khaokhao khao - swaallloooow!" (21). Now it had quite a journey through the food pipe and stomach and small intestine and large intestine - "Migggle mgimgi lleglge" - untill it went into the blood and round and roundandround and here and there, until it found itself sitting near the surface of the skin. It got hot and more hot and so hot, that it joined with other water molecules and became sweat that evaporated from the skin. Then it rose higher and higher in the air "Oooper oooper ooooper," (22) and then . . .

Know these words

flow float sink mix dissolve filter

Water is a **liquid**. Liquids are things that flow.

Liquid turning into vapour is called **evaporation**.

When you heat water it **evaporates faster**.

Water vapour is a **gas**. It mixes with other gases in the air.

When you cool water vapour it **condenses**.

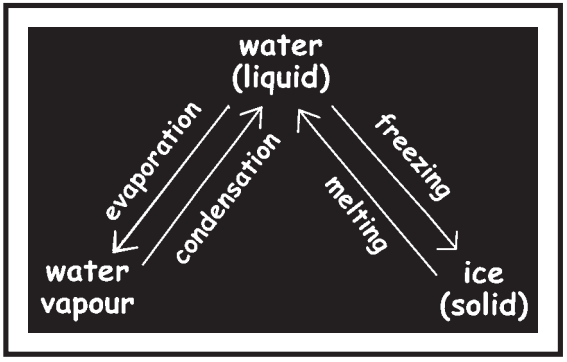
Vapour turning into liquid is called **condensation**.

When you make water very cold, it turns into ice. Ice is a **solid**. Solids do not flow.

Classroom experience

I introduced these new words by drawing a diagram on the blackboard.

BLACKBOARD WORK

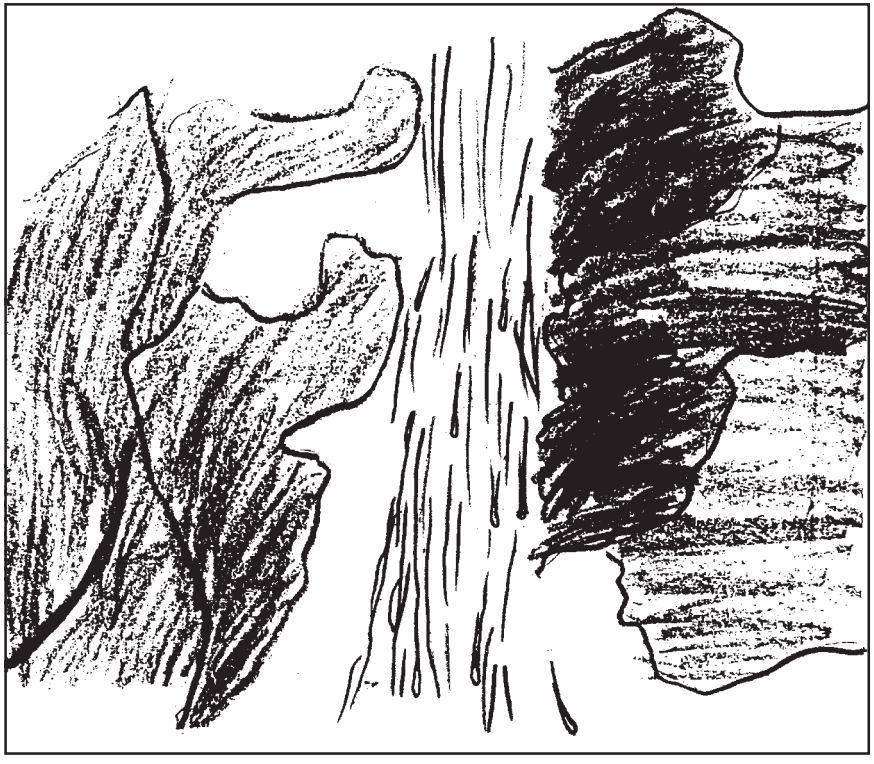


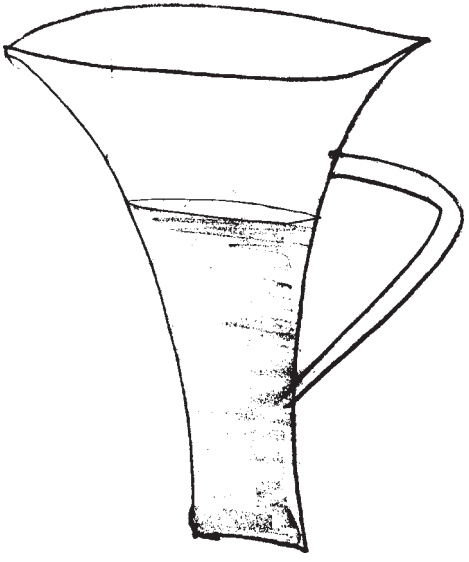
Observation-based exercises

EXERCISES (12 periods + homework; WB p. 85)

Name and draw

1. Flowing water
2. Water that is not flowing



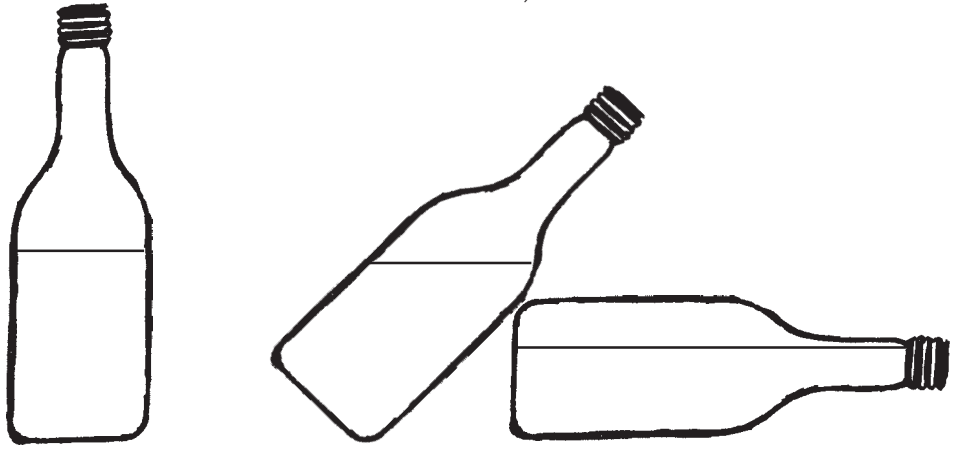


The drawings were done with Activity 1. Initially their pictures indicated movement only by the surrounding context or by labels, e.g. 'flowing' water was shown as a long stream drawn across the page, while 'not flowing' water was shown confined to a small area on the paper. When I asked how, by just looking at the water, they could tell if it was flowing or not flowing, they drew waves and whirlpools in the 'flowing' water and shaded the 'not flowing' water with flat lines. Such drawing activities could lead students to observe carefully and to think of questions like, why mountain streams, or rivers in flood, flow faster, to observe the difference between streamlined and turbulent flow, etc.

Some students recalled their geography lesson by drawing streams flowing down from mountains, merging into a river and then meeting the sea, complete with a delta and estuary at the end. Surprisingly in the discussion (p.159), I found that they had not understood the connection between slope of the terrain and flow of water.

3. Draw the water levels in the bottles in your WorkBook.

This task was surprisingly difficult for some students. A correct response is shown below (note the amount as well as the horizontal surface):



1 **2** **3**

Interesting questions (WB p. 87)

1. Name some things that you have seen moving in a stream of water.

Done with Activity 2.

2. What games can you play with water?

The students had splashed and played in water. They talked about swimming, 'water fighting' and 'water football'. Some had been to a recreation park with a 'water slide' and had seen surfing and water skiing on TV. Organised sports were discussed in *Ask and find out*.

3. Name three things which float and three things which sink in water.

Float: blown balloon, wooden pencil, candle, thermocol, paraffin wax, butter ...

Sink: eraser, steel spoon, stone, brick, glass ...

We also found things that first floated and then sank - razor blade, needle (and cotton, for a different reason); also some seeds which floated and others which sank.

4. Name some solids, liquids and gases that dissolve in water.

Solids - salt, sugar, jaggery; Liquids - milk, lime juice (part solution / part suspension), spirit, alcohol, many acids; Gases - oxygen, chlorine, carbon dioxide, sulphur dioxide, nitrogen dioxide, (All these gases except oxygen react with water to form acids. Chlorine gas is dissolved in water to disinfect it; the last three gases are some of the products of fossil fuel combustion (see pages 133-134); sulphur dioxide in the atmosphere dissolves most easily in water leading to the problem of acid rain.)

5. Name some solids and liquids that **do not** dissolve in water.

Solids - chalk, sand, glass, steel, rubber, plastic; Liquids - kerosene, petrol, cooking oil ...

6. If you keep some water boiling, after a while you see less water. Where does this water go?

See Activities 6-8.

7. Where have you seen a mist? What was the mist made of?

Mist, like clouds, is made of tiny droplets of water suspended in the air. You can see mist near boiling water, near a waterfall, near big waves in the sea, or in the air on a very cold morning. One student mentioned seeing a rainbow in a mist near a waterfall.

8. When wet clothes dry, where does the water go?
9. Suppose you keep three wet shirts out in the sun. One shirt is folded, the second is spread out and the third is kept inside a plastic bag. Which shirt will dry first, second and third?

i. Spread shirt, ii. Folded shirt, iii. Shirt in plastic bag (the last would probably smell bad indicating growth of fungus and bacteria - particularly the kinds that grow in the absence of air)

10. Guess which will evaporate faster:
    a. hot water or cold water?
    b. water in a cup, or water poured into a plate?
    c. water in a covered plate or in an open plate?
    d. water in a windy place or in a calm place?

Questions 9 and 10 might be answered from experience, or reasoning, or they might lead students to design experiments easily done at home.

11. Would you see drops of water on a warm soda bottle or on a cold one?
12. Name some other liquids.

See Activities 7 and 3b.

13 (additional question). Which will evaporate fastest: water, oil or kerosene?

> All liquids evaporate. Methylated spirit (used by doctors to clean the skin before giving an injection) feels cool on the skin. Evaporation uses the body heat. Spirit feels cooler than water because it evaporates faster and so takes away body heat faster than water does. Alcohol and Kerosene too evaporate faster than water while oil evaporates the slowest. In practice however it is difficult to observe the evaporation of oil. Vegetable oils are a mixture of several components some of which are volatile, as we know because we can smell the vapours. But most organic oils when exposed to air first oxidise or undergo some other chemical change: rather than evaporating completely they leave behind a sticky solid residue.

Classroom discussion (WB p. 88)

1. Does water sometimes move from lower to higher level? Is this water moving from a higher to a lower level, or from lower to higher:

waterfall, river, evaporation, rain, fountain, a running tap,

water pumped out from a well, water pumped into a high tank.

What about the water in these pictures:

See discussion on pages 158-159.

2. If there were no wind, would there be rain?

Having completed the weather and air Units students were prepared for this questions. They responded that clouds blow with the wind - if there was no wind the rain clouds would not come - this is certainly true for the monsoon rain. But if water evaporated from a large lake or sea and went up high to form clouds, it might rain there though there was no wind. Large equatorial forests give out a lot of water vapour from their leaves leading to such local rain.

3. We use water for cleaning and washing things. Could we use any other liquids for cleaning? Why or why not?

Water is the best known solvent - it can dissolve many kinds of dirt. It also sticks to most surfaces, so it can carry away dirt. In combination with soap, water even sticks to oil. Water is safe, cheap and abundant on earth.

'Dry cleaning' uses solvents other than water for cleaning clothes. Natural fabrics like wool and cotton tend to swell in water and shrink on drying. For such fabrics kerosene is preferable to water; besides, kerosene removes some stains which are not removed by water. Kerosene has now been replaced in dry cleaning by other less flammable solvents. Alcohol, acetone and carbon tetrachloride are used in the laboratory to dissolve organic substances.

What's the same? What's different? (WB p. 89)

1. Give two similarities and two differences between:

a. Water and water vapour

Both are forms of water. Both make things wet. They are colourless. A collection of small drops of water looks white like a cloud. Water is a liquid, water vapour is a gas. Water vapour is lighter than water - it mixes with the air while water flows down.

b. Ice and water

Both are forms of water. They are colourless (ice with small bubbles or cracks in it looks white). Ice is a solid, water is a liquid. Ice is lighter than water (as you know from observing that ice floats on water).

2. Find the odd one out:
a. water, salt, diesel, honey
b. stone, glass, plastic, sugar
c. wood, iron, butter, oil

Some possible answers are:

a. salt, because it is not a liquid
b. sugar, because it dissolves in water
c. iron, because it sinks in water

A lump of iron sinks in water, but a boat made from iron floats. The densities of different varieties of wood range from about 0.2 g/cc to 1.4 g/cc. Although most woods have density less than 1 and therefore float on water, some, like dry desert ironwood, mountain mahogany and ebony are heavier than water and so sink in it. Another example is 'Anjan', the heaviest wood found in India.

Language-based exercises

Talk and write (WB p. 90)

1. I played in water on a rainy day

Play with words

1. Here are some action words. Do they describe air, water, or both air and water? Give examples.
splash blow flow drip run fall

Water: splash, flow, drip, run, fall ... also leak, ooze, squirt
Air: blow, flow ... also leak, diffuse

2. Make sentences using the action words below. Do your sentences describe things moving on land, water or air?

   roll slide float glide sail fly dive

Commonly the motions are as follows.

On land:	roll, slide
On/ in water:	float, sail (boat), dive
In air:	float, glide, sail (kite), fly, dive

Ask and find out (WB p. 91)

1. What are **water sports**? Have you played or watched any water sports? Find out about some water sports played in different parts of India.

In our country there are few organised water sports. One example is that of boat races in the North Eastern region and in the backwaters of coastal Kerala. Here a network of lagoons and waterways is at times the only means of trade and transport. Children even travel to school by boats.

The Kerala boat races are held in the months of August and September. The largest of the boats are about 130 feet long and carry more than 100 rowers who row together singing rhythmically. The wooden boats are rubbed with fish oil to make them glide fast and smoothly through the water.

2. Find out about any festival celebrations in which water is used.

Water is indispensable to most cultural and religious rituals. Students knew a few examples like, Holi, Id, and the use of *Ganga-jal* and of holy water in Baptism.

Quantitative thinking

Figure it out (WB p. 91)

1. The amount of a liquid is called its **volume**. We measure the volume of water, milk, kerosene and diesel in **litres**. Find a container that holds about one litre of any liquid.

Conceptual problem

In Small Science Class 3 students had worked with informal measures of volume. I emphasised that 'volume' of a liquid is how much space it takes up. A container that holds '1 litre' of water holds the same volume of any other liquid. This apparently simple fact was not clear to most students, nor the idea that 1 litre of another liquid might weigh more or less than a litre of water. After this discussion however students started looking around them for various situations involving volume measures (listed on pages 225-227, Chapter 7, Activity 4).

2. Find out the weight of one litre of water in kilograms.

In Class 4 it is too early to introduce the concept of density, since (as we saw above) students still confuse 'volume' with 'weight'. But they could start now collecting facts and experiences. They should know that a litre of water weighs about 1 kilogram and that other liquids might be heavier or lighter than water.

> The density of water changes with temperature. The maximum density, which occurs at 3.98°C, is 1.00000 g/cc (or kg/litre). At 25°C the density is 0.99707 kg/litre; at 100°C is the minimum density which is 0.95838 kg/litre. Kerosene, ethyl alcohol and acetone are lighter than water. One litre of any these liquids at 20°C weighs around 0.8 kg; one litre of glycerine at 20°C, 1.2613 kg; one litre of mercury at 25°C, 13.534 kg!

3. Mini mixed some mud with water, stirred it and kept the mixture aside. After a few minutes most of the mud settled to the bottom, while dried bits of grass floated on the top. Mini wondered, "Did some part of the mud dissolve in the water?" How would she try to find out?

If some of the mud is suspended in water the mixture would look cloudy. If allowed more time the mud might settle, or it could be settled with the help of alum. Anything that is dissolved in the water would leave a residue on evaporation. Now how would Mini find out whether the residue came from the dissolved part of the mud, or if it was there in the water to start with, or perhaps it is just the dissolved part of the alum?

Show and tell

1. Find some water in your classroom. Imagine and tell a story about how this water might be part of a water cycle. (Where might this water have come from? Where could it go?)

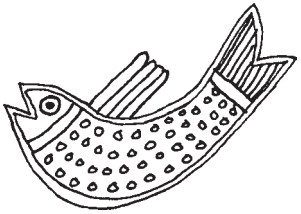
Water in a bottle or pot might form the starting point of this description, or even water in our own body (which is derived from our food and water intake). While doing this activity students realised they did not know clearly where the water in their homes came from. This stimulated them to ask some questions which helped later in the discussion on water sources in Chapter 7.

Ask a question (WB p. 92)

1. Ask questions about water. Think of how you will try to find the answers.

Students' questions

Why does steam go up? (Hot air being light, i.e. 'less dense', rises up and steam rises with it.) The same is true of water evaporated by the sun's heat and of smoke going up a chimney and out from it.



CHAPTER 6

Water and life

STORY (2 periods; TB p. 56)

The Fish Tank

Mini and Apu were very sad when their two pet fish died. They buried the fish in the garden, but the tank remained on their window sill. A month later, they were surprised to see fine green threads growing in the water. They also found some insects wriggling inside the water.

"Where did these water plants and these insects come from?" Mini asked.

"The plants might have been in the tank before. They were so small that you could not see them." Amma said. "Fish eat these plants even when they are very small. Now that the fish are not there, the plants have grown!"

"And the insects?" Apu wondered.

"Mosquitoes might have laid their eggs in the tank. Out of a mosquito egg comes a larva, which changes into a little pupa that finally turns into a mosquito. The little insects you see in that water are larvas and pupas."

"The fish might be eating them. That is why, when the fish were there, there were no little mosquitoes!" Mini exclaimed.

"Less mosquitoes to bite us and spread diseases," Apu said. "The fish are really useful."

Suddenly Mini remembered something. "Amma, you told us that where there is water, there is always life of some kind."

"Yes, we found so many living things in the rainy season!" Apu said.

Classroom experience

The ideas in the story were somewhat difficult. Students had to know a little about life cycles to understand how other life had arisen after the fish had gone. Some students who kept pet fish could relate better to the story. I recalled the story of the pea caterpillar in the Class 3 Small Science book to explain that mosquito larvae come out from mosquito eggs just like caterpillars come from the eggs of butterflies and moths.

Grey clouds,	*New green plants,*	*Logs are mossy,*
Wet showers,	*And pesky flies,*	*Earthworms thrive,*
On the muddy pond,	*Tadpoles swim,*	*This is the play,*
A dragonfly hovers.	*The first frog cries.*	*Of water and life.*

Monsoon is the mating season for many animals. Female frogs lay their eggs in water where they are fertilised by the male. The tadpoles that hatch out live and feed in water till they metamorphose into adults. Dragonflies mate flying above water, swooping down to drop their fertilised eggs in water. Their larvae too live in water and crawl out only when it is time to moult into an adult. Water is essential for reproduction in mosses.

Cocoons of earthworms lie dormant in the dry soil and hatch when it rains. The adult earthworms, who had burrowed deep down in the dry season to avoid being dehydrated, also come into the top layer of soil when it rains. They usually come out of the soil only at night but with too much rain their burrows get flooded and they are seen outside even during the day.

Difficult words in the story and poem:

wriggling, pesky, thrive

ACTIVITIES

Water for living (TB p. 57, WB p. 93)

1. Water in living things (Double period for 1a-1d; Double period for 1e-1f)

Preparations for Activities 1a-1d

Students had brought several kinds of flowers and leaves. In the beginning of the class we kept a set of flowers and leaves out in the sun and tied plastic bags to leaves of different plants.

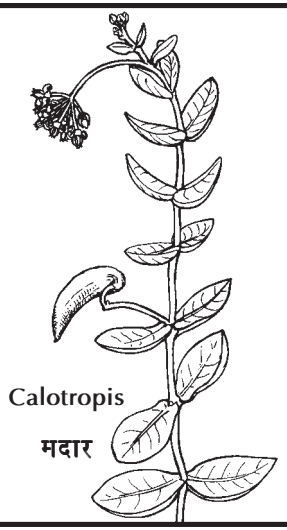
Before starting the discussion, I asked two students to prepare the cucumber and brinjal pieces. Since I did not want students to handle knives in the classroom, they did the cutting and carving using spoons as shown in the TextBook (cheap spoons made of thin steel are better).

Students' observations

I recalled that plants take up water through their roots: "Where does this water go? Does it go out of the plant? Does it stay in the plant? If so, in which part of the plant? Is there water in this (part)?". They said that there must be water in roots because it is the roots which take water from the soil. One student objected saying that roots look very dry.

At this point one of the students stood up and said excitedly, "You **can** get water from roots, if you pull up a small plant, wrap the roots in a cloth and crush them with a stone, the cloth gets wet!" Everyone was surprised at this response: this student, though very active, rarely speaks in class. It was clear he spoke from experience. Later many students added that the stem, leaves and flowers of plants also had water - you could crush them and get a watery fluid. We assumed that this liquid was water with some things dissolved in it.

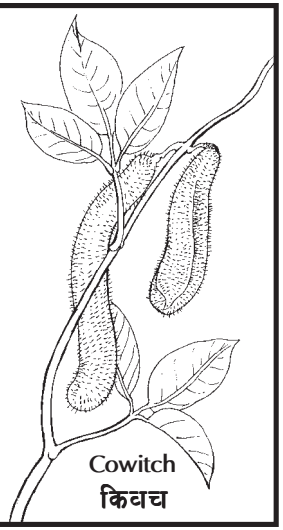
a. Pluck a leaf or a petal of a flower. Crush it between your fingers. What do you see and feel? Do you think there is water in leaves and petals? (WorkBook page 93)



Take Care!

When you pluck a leaf or a flower, make sure there are many of the same kind remaining. Do not spoil a garden or kill a plant.

Do not crush unfamiliar wild leaves or flowers. Some of them might harm you. The juice of the ***Calotropis*** *plant is poisonous.* ***Cowitch*** *gives you a very bad itch.*



The crushing activity is best done with garden and edible plants - one should be cautious with unfamiliar plants. The sap of the Ak or Rui (*Calotropis gigantea*) plant is poisonous. The Common Cowitch or Khajkuiri (*Mucuna prurita*) is an annual plant, a slender climber whose long curved pods resemble the tail of a squirrel. The bristles on these pods cause intense itching if they touch the skin. The seeds, though poisonous, are of great medicinal value. Hairs on the Indian stinging nettle (*Tragia involucrata*) and common nettle (*Fleura interrupta*) also cause itching.

Classroom experience

The activity was done in groups. A small piece of leaf or flower was sufficient to check the water content. Soft leaves like vinca and hibiscus and all the edible leaves like palak and coriander gave out a large amount of water. Leaves of champa and thuja which are hard gave out very little water when crushed. Petals of softer flowers like rose gave out more water than flowers from dry scrub plants. It is interesting that, like us, cows and caterpillars too prefer to eat the softer and juicier leaves.

b. Scoop a piece out of a cucumber or a brinjal to make a cavity. Rub a big pinch of salt inside the cavity. Watch for about 10 minutes. Look again after a few hours.

Students' observations

Students knew that when you put salt on cucumber, it becomes watery. They had not thought of where this water came from. Some guessed it came from the air, just like water outside the cold-drink bottle. Others suggested that even plain salt might get wet if left open, so we tried this out. At the end of the class the salt looked as dry as before (impurities in common salt do absorb water from the atmosphere so sea salt tends to get wet if left open for a long time). Then one student said that when you cut cucumber and radish the knife becomes wet so the water must be in the vegetable.

By the end of the class the cucumber bowls were half full of water; by the next day they were completely full. One student suggested that we put salt on vegetables which did not look so watery, like beans, and on different leaves and flowers: they did this at home. Leafy vegetables showed water droplets some minutes after being rubbed with salt (sugar did not have this effect). Other leaves and vegetables which apparently had an oily or waxy coating did not give out much water.

The food we eat consists largely of water. The approximate water content of some common foods is given below. Notice that spinach contains more water than milk. Foods which contain less water are usually the ones to which we add water while cooking.

Food	Moisture % by weight	Food	Moisture % by weight
Spinach	92.1	Wheat flour	12.2
Cow milk	87.5	Jeera (Cumin)	11.9
Onion	86.8	Toor dal	9.9
Carro	86.0	Groundnut	7.9
Banana	73.4	Roasted groundnut	4.0
Uncooked rice	13.5		

c. Leave a freshly plucked flower and some leaves out in the sun for a few hours. How do they look? Why do you think they look different now?

Classroom experience

The flowers and leaves kept in the sun looked wrinkled and showed less water when crushed. I asked students whether the weight of these leaves might have changed.

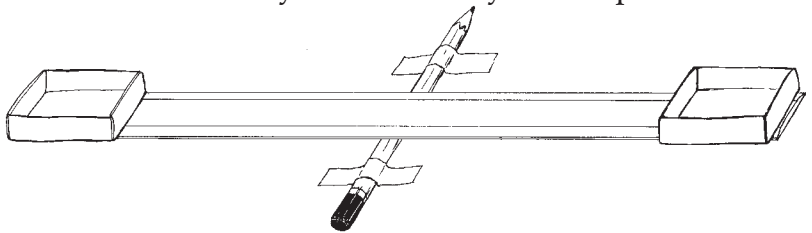
d. Put a large clear plastic bag around some of the leaves of a plant. Tie the mouth of the bag with a thread. Look at it after a few hours.

Classroom experience

This activity demonstrated that water continuously goes out even from a living pant. Some water collected in the bags by the end of the class; at the end of the day there was a lot of water. Interestingly the thuja and champa plants, with hard leaves that did not show much water when crushed, collected the maximum amount of water. The bag tied to the cactus plant was dry! After two more days, it still did not show any trace of water. We also kept some bags tied overnight and found less water collected at night compared to the water collected during the day.

> Water vapour comes out through openings on the leaf surface called stomata. Since stomata are closed during the night very little water vapour is given out. Plants of the evergreen rain forests have large, broad leaves with many stomata, through which they lose a lot of water. Plants growing in regions where water is scarce have very small leaves - thorns are the leaves of the cactus plant. They lose very little water. In wet regions some cactuses grow broad leaves enabling them to lose excess water.

e. Make a balance like the one you made last year (TB p. 58).



Pluck two similar flowers. Keep them on the two pans of the balance. If one of the flowers is heavier, cut off a little of the stem until they balance.

Now keep one flower with the stem in water. Leave the other flower outside the water.

On the next day wipe the stem of the flower which was kept in water. Put the two flowers in the two pans of the balance. Now do they weigh the same? Why is there a difference?

Carefully add water with a dropper to the lighter side till the pans balance again. How many drops of water did you add? Can you guess how much water the flower lost in one day? (WorkBook page 94)

Observation and interpretation

The experiment showed that the weight of the dry flower was less than of the flower kept in water. Eight drops of water had to be added to the dry flower for the weights to be balanced. This gave us an idea of how much water might have been lost from the dried flower.

But there was some doubt about this interpretation. The other flower must also have lost water, which was replaced by water absorbed through the stem. Since the flower looked the same as it did when fresh we assumed (though we could not be sure) that the sum total of water gained and lost was zero. Only then we concluded that eight drops of water were lost in drying. To be more sure, we would need to weigh the flowers before and after with an accurate balance.

There were other questions in my mind which however I did not raise in class. Surely other physical and chemical changes took place on drying - the colour and smell of the leaves and flowers also changed. Was the weight loss entirely due to loss of water, I wondered.

f. Put a few spoons of writing ink in a glass. Add an equal quantity of water.

Take a white or light-coloured flower with a stem. Keep the stem in the mixture of ink and water. Look at it after about an hour.

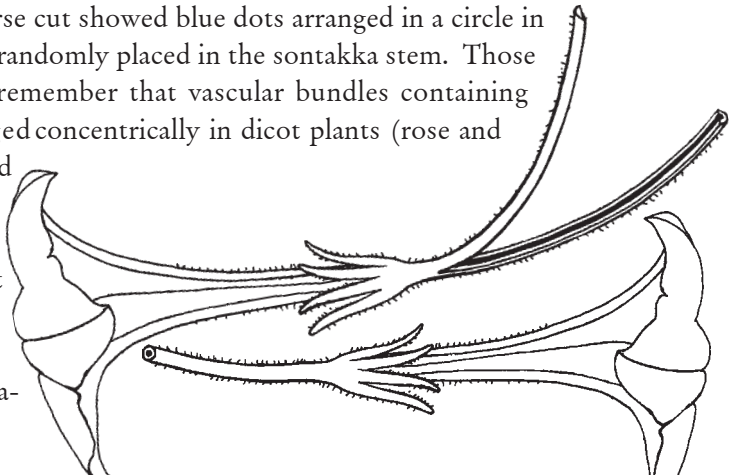
Cut the stem of the flower. See how the ink went up the stem to the flower (WorkBook page 94).

Classroom experience

We did the experiment with water-soluble blue ink. Earlier I had tried insoluble ink and found that it did not work. Equal proportion of ink and water worked well. If the solution was too dilute, it was difficult to see the colour.

We kept three kinds of flowers (rose, sontakka and champa) in the ink at the beginning of the day, after which the students continued with their other work. In the rose we noticed the colour after about one and a quarter hour. The sontakka took about one and three quarter hours while the champa took two hours.

We could cut the stems lengthwise as well as across (as shown below). The lengthwise cut showed fine blue lines (of xylem tissue) along the stem showing where the ink had gone up the stem. The transverse cut showed blue dots arranged in a circle in the rose and champa stem, and randomly placed in the sontakka stem. Those knowing some botany might remember that vascular bundles containing conducting tissue are arranged concentrically in dicot plants (rose and champa) while they are scattered in the stems of monocot plants (like sontakka). In Class 4 it is enough to tell students that water and minerals in the soil are carried to different parts of the plant through tubes comparable to our blood vessels.



g. Do you think animals have water in their bodies? Remember some experiences to support your ideas (WorkBook page 94).

From observing live and dead animals it is easy to see that they contain liquid matter. We can guess that this must be water.

2. Water inside our body (1 period; TB p. 59, WB p. 95)

a. Hold your mouth close to a mirror, a window pane or a piece of glass. Breathe out gently. What do you see on the glass?

In cold weather you might see near your mouth a cloud of tiny water droplets.

Where did this water come from?

Classroom experience

Most students had experienced the mist of water in their breath. They knew of breathing on eyeglasses to clean them. In cold weather the water vapour from our breath condenses into droplets making a little cloud. The water drops can be seen clearly on a cold glass surface.

b. Loosely tie a dry plastic bag around one hand. Remove it after 10 minutes. What do you see inside the bag? (WorkBook page 95)

Classroom experience

This was a striking and surprising experiment. In five minutes we saw tiny water drops condensed on the inside of the bag. Depending on the temperature and humidity on that day it may take more or less time for the water drops to become visible.

About 70-90% of the weight of a living cell is water. Animal and plant cells are bathed in a fluid which is largely water. The proportions vary for different kinds of tissue (group of cells) but even bone contains about 30% water. Our bodies work with the help of hundreds of thousands of different molecules travelling within and between cells in order to perform different jobs. Molecules of digested food, salts, carbon dioxide and many organic com-

pounds dissolve in water and thus can be carried about inside our body.
If we get too much or too little water, the dissolved chemicals become either too dilute or too concentrated; one way our body tries to cope is by producing either more or less urine. Normally the amount of water we drink is the same as the amount we let out from our body. On a very hot day, during fever or loose motions we need to drink a lot of water (with salts) to compensate the extra loss. The daily water balance in the body when there is no visible perspiration is approximately as below:

Water intake

1500 ml.	Drinking
300 ml.	Water in food
600 ml.	From break-up of food molecules

Water let out

1400 ml.	Urine
100 ml.	Water in faeces
900 ml.	Water let out through lungs (in breathing) and skin

Think! Think!

All living things have water in their bodies. They need water to live. But all of them do not drink water! Ants do not drink water, nor do the little grubs that live in grain. Where do you think they get water from?

Some insects live on very watery foods like nectar (butterflies, moths), plant sap (aphids, mosquitoes) and blood (mosquitoes, bed bugs, fleas and lice). But most insects who eat apparently dry food also get some water from their food. Even dry grains contain about 10% water by weight. Besides this free water, insects get water from the breaking-down of nutrient molecules during metabolic activity. Water is released when fat, carbohydrate and protein molecules are broken down inside their body cells.

Aim of the activities

Through Activities 3 and 4 students are exposed to quite a lot of new information, through field observation and in pictorial form. The pictures are meant to arouse curiosity, convey a few general points and prepare some background for later learning (see Objectives on page 154, especially 3.4, 3.5 and 3.6):

Through the pictures and activities students should find out that fresh and salt water areas, and places with very little water, all have their characteristic life-forms. Some adaptations which help these plants and animals to survive and thrive in more or less water are mentioned in passing (*Did you know*). In later classes they will learn about other factors like temperature and soil conditions, the specific adaptations and their evolutionary significance. Right now the aim is just to observe carefully and notice the variety of living things characteristic of obviously different environments.

> A wetland is a region of land covered most, or all of the time, with shallow water. Examples of wetlands are marshes, swamps, flood plains of rivers, areas surrounding ponds and lakes, lagoons and backwaters. They may contain fresh or salt water. Many unique animals and plants live on wetlands. Wetland plants prevent erosion, add nutrients to, and remove pollutants from the water. Like other large bodies of water, wetlands help stabilise the climate and also absorb carbon dioxide from the atmosphere. They protect coastal areas against storms and cyclones. Many wetlands in our country are endangered due to urbanisation, but after the destruction caused by recent cyclones people are slowly becoming aware of the importance of coastal wetlands.

3. Living things in water (2 periods + field trip/ observations; TB p. 59)

Field trip

The following account of the trip is taken from Dr. Karen Haydock:

Even in a dry region, water plants and animals might be observed during the monsoon season. The field trip was to a wet marshy area near our school. Students had come prepared with empty jars. Before going out I gave the following instructions: (i) Write down (in your WorkBook) which animals and plants you expect to find in a wet, marshy place with puddles. (ii) Add to or subtract from your list when you get there. (iii) You

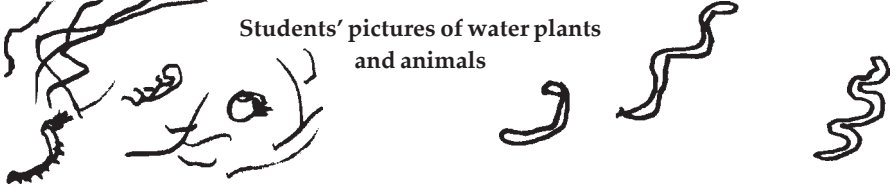
will be out for only 45 minutes, so get to work right away drawing, labelling, and taking notes of whatever you see. (iv) If you do not know the name of something, just describe it. (v) Your work will be marked: those who have the most pictures, labels, and descriptions, and have observed most carefully will get the highest marks. (vi) At the end collect water from different places in your jars - include some plants also. (vii) As soon as you get back wash your hands and the outsides of your jars.

I took pains to ask them what precautions they should take. They said they would have to stay together, be disciplined, be careful of tall grass because of snakes and other small animals, be careful of dogs, be careful not to fall in water, be careful of mud, etc. (I noted the main points on the board).

Later I realised that for this urban upper middle-class student group the warnings about running around in the mud may not even be necessary - almost all the students were afraid to step anywhere or touch anything. Many of them needed continuous encouragement to keep looking. I had to go around asking questions, reminding them to observe and to draw more carefully. None of us had much idea about the names of things - which was alright - if I or the other teacher had known these the students would have been busy copying down names instead of observing.

The underwater plants were algae (2 or 3 different kinds) and some tiny plants that float on the surface (with 3 roundish leaves about 2 mm in diameter and a 1-2 cm root hanging down. The partly in water plants were different kinds of grass, reeds (there were cattails, surprisingly), one or two flowering plants, etc.

The animals were three different kinds of dragonflies, butterflies, something that was either a fish, a developing frog or some kind of water insect, mosquito larvae, various insects that flew around the surface of the water, eggs of some kind, etc.



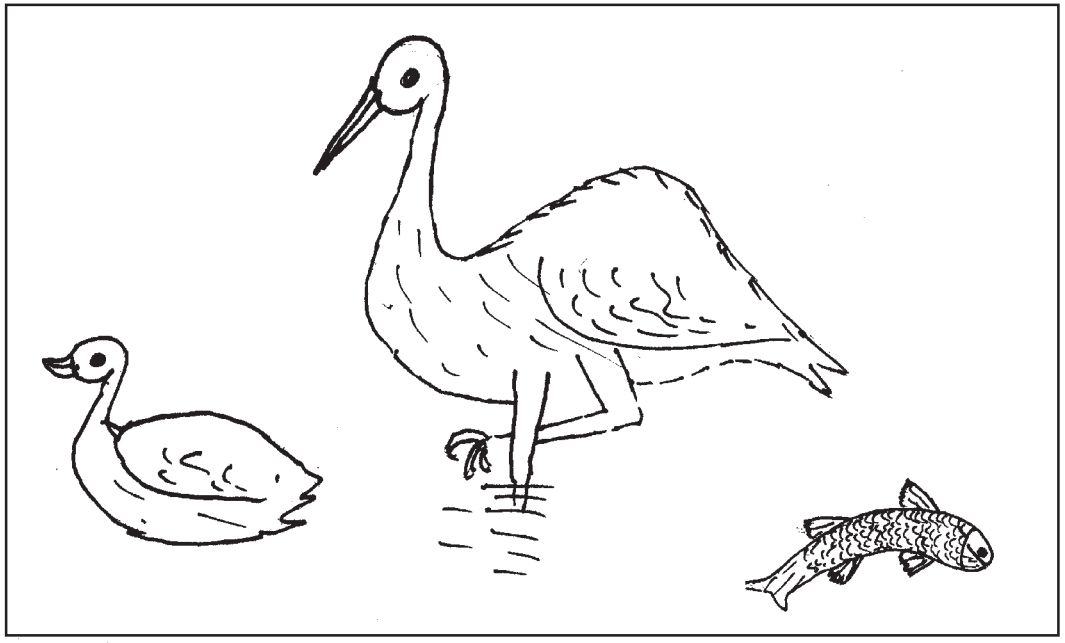
Students' pictures of water plants and animals

Some common water animals and plants are drawn in a. and b. below. These pictures are meant for identification and so are different from the students' more informal or impressionistic drawings. Students should be encouraged to draw from their own observation and not copy these or any other pictures.

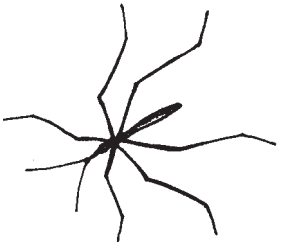
a. Write the names of some animals that live in water.

Students' observations

Besides the observations in the field trip, students had seen waterboatmen (insects gliding on water), small fish, mosquito-like flying insects, frogs, water hen, ducks, kingfisher and egrets and also a few plants like water hyacinth and mosses. They had their own names for these. From books and TV they knew of other animals living in water like octopus, shark, whale, etc.



midge nymph



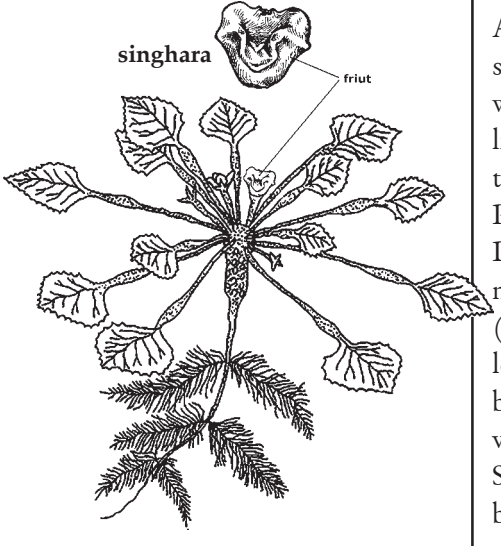
water skater

water boatman

b. Look for plants growing in water. Try to find a plant that is completely under water, and a plant that is partly underwater and partly out of the water.

Describe and draw pictures of each plant you find. Try to find out the names of these plants (WorkBook pages 95-96).

There were thousands of these tiny plants floating on the surface of puddles.



Examples of plants completely under water:

Algae are simple plants, ranging in size from the microscopic diatoms (described on page 208) to giant seaweeds which can grow 60 m in a year. Under water we also find more complex plants, often just called pondweeds. Some like hydrilla have no roots while others like vallisneria are rooted at the bottom.

Plants floating partly above water:

Duckweed and water chestnut (the edible *singhara*); water hyacinth is a common weed with floating leaves and roots usually dangling free in the water (some species are rooted to the bottom). A spongy bulb at the base of the leaves helps it to float. This plant was brought to India in the 19th Century because of its beautiful purple flowers. Too late people realised that it grows very fast choking off large areas of lakes and rivers.

Some plants float when the water level is high but during the dry season become rooted to the wet soil. Sometimes the same plant has both floating and submerged leaves.

Plants with roots in the soil and tops well above water: reeds, lotus, water lilies, mangroves.

c. Look for small living things in water. Fill a glass jar with water, plants and other living things from a pond, tank, puddle or stream. Observe the living things, describe them and draw what you see in your WorkBook on page 96. Use a hand lens if you have one. Wash your hands well after handling dirty water.

Take water containing living things from different places, and compare it.

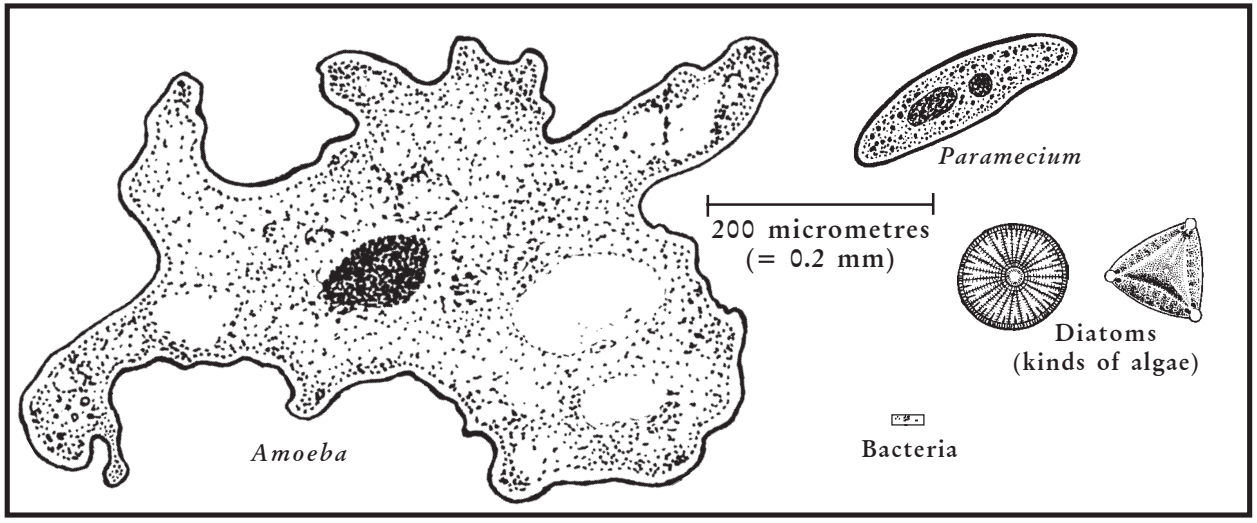
Keep the water for a week. Observe it every day and note any changes (WorkBook page 97).

(See account of field trip, pages 202-203)

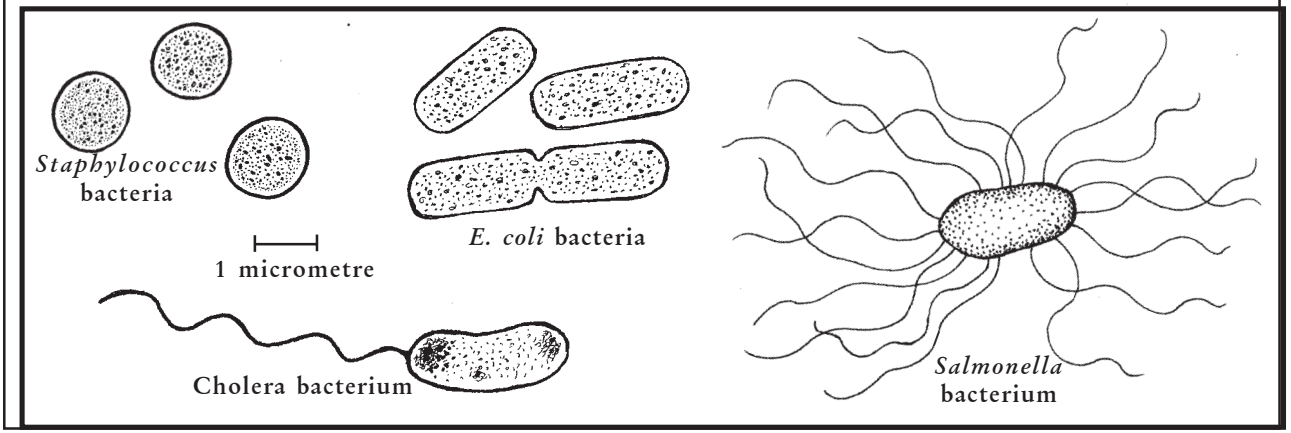
The results might well parallel Mini and Apu's experience in the story at the beginning of this Chapter. It is best to collect water from a puddle or the edge of a pond. Water from around dead leaves and plants is likely to contain microbes which multiply in the container. After two days the inner surface of the glass may have a slimy feel. The 'slime' growing around the sides of the container is made of microscopic plants including moss and algae. Had this water remained in the pond, a lot of the moss, algae, microbes and larvae would have been eaten by natural predators such as fish and tadpoles.

The activity does not work as well with tap water, in which dissolved chlorine prevents the growth of microbes. To get a large number of microbes like the ones described in Activity 3d. next, keep some dried or rotting leaves in water for a week.

d. If you look at pond water through a microscope you find even smaller living things called **microbes**. Here are some pictures of microbes.



Here is a more close up view of the bacteria in the box in the above picture:



Microbes need water to live. Dry places have fewer microbes. Drying things in the sun kills microbes.

In the middle of the 17th Century Antony van Leeuwenhoek, a Dutch cloth merchant, looked through a microscope at drops of water from rain, wells, sea and melting snow. He was surprised to see in all of them what he called little animals. The picture on the top of the previous page, also given in the TextBook on page 60, shows some living things that might be seen under a school microscope. Bacteria are much smaller, seen only as dots in the tiny rectangle in this picture. Different kinds of such amoeba, paramecium, diatoms and bacteria are found in moist soils, pond water and oceans.

Amoeba: looks like a blob of colourless watery jelly continuously moving and changing its shape. Inside is a dark speck (the nucleus). The amoeba moves by making its watery body flow: it feeds by flowing around the food to surround and 'swallow' it. *Amoeba proteus*, commonly found on the underside of floating leaves, feeds on smaller microscopic plants and animals including paramecium, diatoms and bacteria. Another kind of amoeba (*Entamoeba coli*) lives and feeds harmlessly in our intestines while if *Entamoeba hystolytica*, found in water polluted by sewage, enters our intestines, it causes amoebic dysentry. An amoeba is about half a millimetre long.

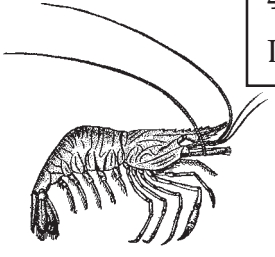
Paramecium: a tiny fast-moving creature shaped like a slipper. It swims with the help of hair-like 'cilia' which it also uses to capture its food eg., bacteria.

Diatoms: a kind of one-celled algae, the simplest kind of plant. The numerous algae found in pond and sea water give it a greenish colour. Examples of common, larger algae are spirogyra, seen as slimy filamentous masses floating on water. Like other plants algae make their own food with the help of sunlight and carbon dioxide. The oxygen which they make in this process can be seen as tiny bubbles sticking between the tangled algae. Algae are food for larger living things in water.

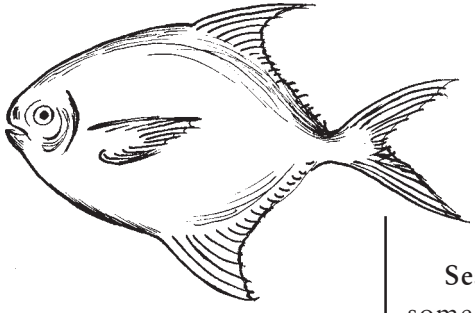
The rectangle containing bacteria is shown at a higher magnification on the bottom of page 207 (TB p. 60). Out of the large variety of bacteria that live in water, only some of those important or harmful to humans are shown in this picture (for more on health consequences see pages 231-232 and 326-327):
Staphylococcus: a spherical bacterium found in air, dust, water, and in many foods like meat, milk and eggs. If food containing these bacteria is kept warm for a long time they multiply and produce poisons which cannot be destroyed even by heating. Eating this food can cause stomach cramps, vomiting or in severe cases, death.
E. coli (the abbreviated name for *Escherichia coli)* is a kind of bacterium found in water, food and on bodies of animals. It is one of the common microbes that live in our large intestines (page 100 (Chapter 10) in the TextBook). E. coli help digest our food and produce Vitamins K and B-complex which are essential for us. However some strains of E. coli (genetically different from the majority of E. coli in our intestines), produce dangerous toxins which can cause severe diarrhoea and internal bleeding.
Cholera bacterium: This bacterium, *Vibrio cholera*, causes severe watery diarrhoea.
Salmonella bacterium: another bacterium found in the intestines and easily transferred to food and water. Some strains are harmful to humans, causing symptoms often mistaken for influenza.

4. Some need more water, some need less (TB p. 60, WB p. 97)

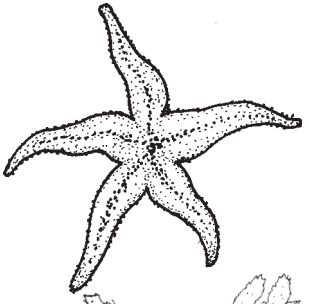
Living things in the ocean:



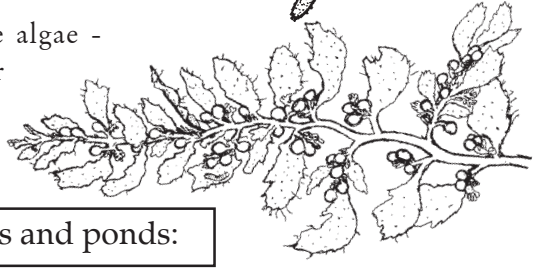
Prawn is an example of a commonly eaten 'crustacean'. Many kinds of crustaceans, like crabs, lobsters and crayfish, are found in both salt and fresh water. They range in size from the microscopic daphnia to large lobsters.



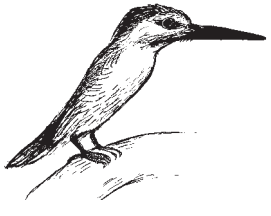
Pomfret is an edible sea-fish. Starfish are spiny star shaped creatures found near the sea-shore during low-tide. Having no front or back end, they can move in any direction without turning.



Seaweeds are kinds of marine algae - some of them are cultivated for food, fertiliser or extraction of chemicals. Some seaweeds have air bladders that help them to float.

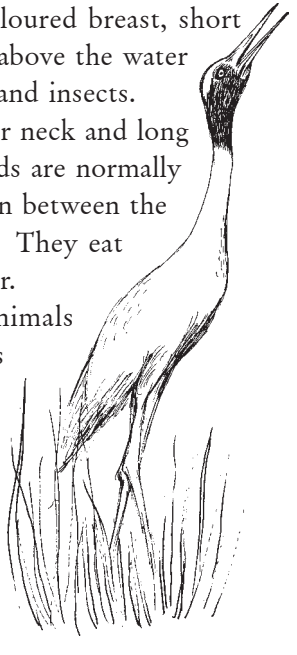


Living things in or near fresh water tanks and ponds:

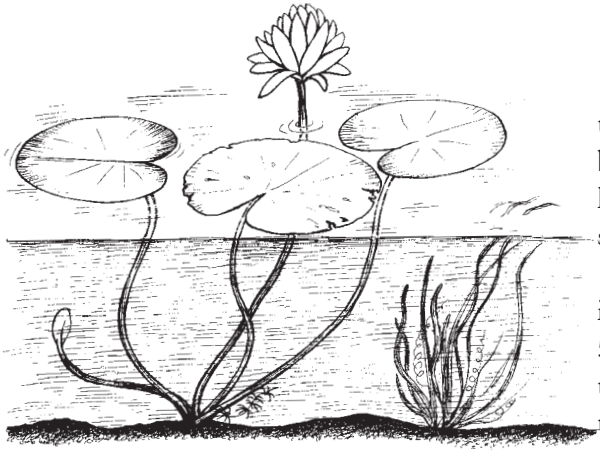


Small blue kingfisher: a blue-green bird with rust-coloured breast, short stumpy tail and long brown beak. It sits on branches above the water and and dives in expertly to catch small fish, tadpoles and insects.

Sarus crane: a tall grey bird with red head and upper neck and long red legs, found in North and Central India. These birds are normally seen in pairs and are popularly admired for the devotion between the male and female and their joint caring for the chicks. They eat grains, shoots, insects and reptiles found near the water.



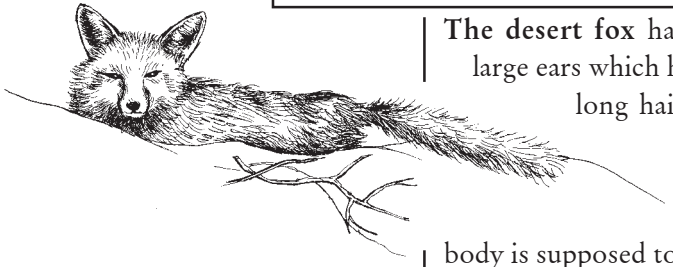
Frog: belongs to the class called 'amphibians', animals which can live on land or in water. Other amphibians are, toads, newts and salamanders. The female frog lays a mass of small black and white eggs in water. The tadpole which comes out of the egg has gills and even looks like a tiny fish. It feeds on algae till it grows into a frog. The adult frog eats insects which it catches with its long tongue.



Lotus: a popular and sacred plant in India since ancient times. Lotus flowers are pink, white or yellow and have a beautiful smell. The flowers close at night. Roots, stem, leaves and flowers of the lotus are all edible. Dried lotus seeds have been known to survive for a thousand years.

Mosquito: The life cycle of the mosquito is mentioned in the story at the beginning of this Chapter (TextBook, page 56). The female mosquito needs to drink blood for the eggs to mature. While sucking our blood it can transmit deadly diseases like malaria, filaria, yellow fever and dengue.

Living things in the desert:



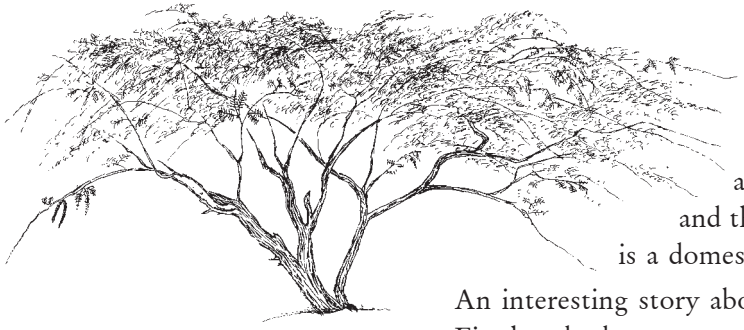
The desert fox has a greyish-brown body, a bushy white-tipped tail and large ears which help it to radiate heat. The soles of its feet are covered with long hairs.

The spiny-tailed lizard is a harmless animal, unnecessarily hunted by humans because the oil in its body is supposed to have magical properties. The body is covered with smooth scales and tail with spiny scales which act as armour. These scales reduce loss of water from the skin. During the hot part of the day this lizard burrows under the sand. When pursued by a fox or a snake, the spiny-tailed lizard crawls into its burrow covering the entrance with its tail.

Locusts are very destructive insects. Every few years their population suddenly grows and huge numbers of locusts fly out from the Thar desert. They travel hundreds of miles in a day. Wherever they alight they eat up every bit of vegetation in sight. In one square mile there could be about 300,000,000

locusts, together weighing 500 tons. Each locust consumes its own weight of plant matter every day!

Desert plants have small and thorny leaves to reduce loss of water by transpiration. In some plants like cactus the stem is thickened to store water. Common plants in the Thar desert are the babul and the **khejri** thorn trees, scrub grass and some berries. Some larger animals (apart from those shown in the pictures) are the wild ass, the black buck, the chinkara deer and the great Indian Bustard (a large bird). The camel is a domesticated animal of the desert.



An interesting story about the **khejri** tree:

Five hundred years ago a man called Guru Maharaj Jambaji lived in Marwar in the middle of the Thar desert. He taught people to care for trees and animals around them. The followers of his 29 tenets are a community called 'Bishnoi' (meaning twenty nine). The Bishnois would rather sacrifice their lives than allow anyone to cut a green tree or to kill a wild animal.

The most revered tree of the Bishnois is the khejri (*Prosopis cineraria*), now the State tree of Rajasthan. According to legend, in 1731 the King of Jodhpur wanted to build a new palace, for which he ordered the felling of a grove of khejri trees in the Bishnoi village of Khejadali. Led by a woman named Amrita Devi, the villagers hugged the trees, protecting them with their bodies. A battle with the royal troops followed, in which 363 Bishnois including Amrita Devi were killed. When the news reached the King he was aghast and impressed. He ordered that from then on the Bishnoi faith would be respected in his kingdom and no Bishnoi village would be asked to contribute timber or wildlife for the king.

All living things need water to live (1 period)

All living things contain water. They need water to live and grow.

Our skin, muscles, blood, bones and even teeth have water in them!

Know these words

aquatic plants

aquatic animals

marsh

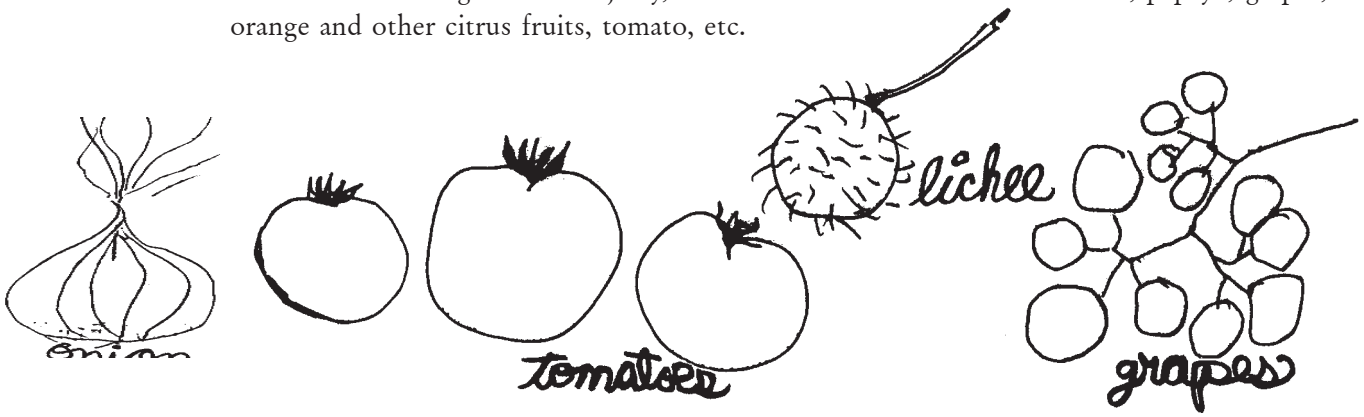
EXERCISES (8 periods + homework; WB p. 97)

Observation-based exercises

Name and draw

1. Juicy fruits and vegetables

Most fruits and vegetables are juicy, but students mentioned water melon, papaya, grapes, orange and other citrus fruits, tomato, etc.



2. A plant that has been given

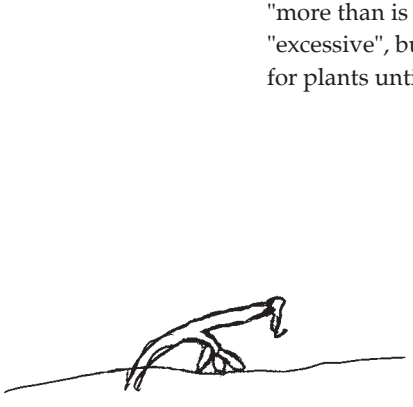
a. no water

b. just enough water

c. too much water

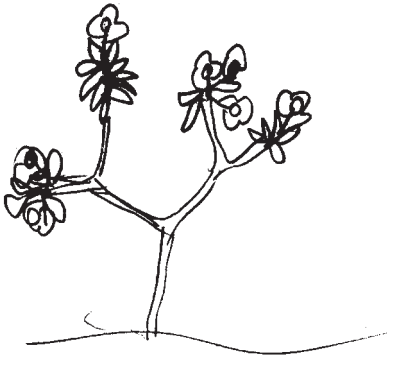
Too little or too much water over a long period is bad for plants. The symptoms of dryness and of excess water might sometimes be so similar that one is mistaken for the other. Both can cause leaves to turn yellow, wilt and drop off. But dryness usually leads to shrivelling and browning while wetness causes yellowing and rotting of the leaves and stems. Some plants have adaptations suited for very dry or very wet conditions (see pages 209-212 and 219).

In Indian English, "too much" often means "a lot." The student who made these drawings used this interpretation. She did not realise that "too much" was supposed to mean "excessive" or "more than is good." Other students did think of "too much as "excessive", but did not realise that too much water may be bad for plants until they tried it out.



no water

just enough water



too much water

Interesting questions (WB p. 99)

1. Suppose you put water on the ground around a plant. Does this water reach parts of the plant above ground?
2. Does the water go out of the plant? How do you know?
3. Which of these different parts of a plant have water in them? Why do you think so?

   root stem leaf flower fruit seed trunk
4. Which of these things have water in them? Why do you think so?

   orange juice a banana a groundnut a roti your body
5. Will a bundle of grass weigh more when it is freshly cut or when it has dried up? Guess why.
6. A sack full of wheat got wet in the rain. What might happen to it in a few days?

Questions 1-6 were done along with Activities 1 a.-f.

7. Name some animals that can swim in water but stay alive even out of water.

All amphibians like frog, newt and salamander (the larva stage of these animals live entirely in water), crab, turtle, crocodile, gharial, otter, beaver, rhinoceros and even a few fish like the mudskipper and climbing perch.

8. Name some animals that live in water and die if they come out of water.

Most fish, crustaceans, other animals with gills like mosquito and dragonfly larvae, larval stages of amphibians ...

Classroom discussion

1. Could a rose plant grow in water like a lotus plant? Could it grow in a desert? What would happen to it?

Classroom experience

Through this discussion students realised that some plants grow only in water while for others too much water is harmful. A rose plant would rot in too much water - its roots would not be able to breathe - and dry up in the desert (by giving out water throught its leaves). In Activity 1d. students had seen how a desert plant like cactus is adapted to a dry environment - unlike the other plants they tested, cactus gave out almost no water through its leaves.

Language-based exercises

Talk and write (WB p. 100)

1. One day when I got very thirsty

Figure it out

1. A farmer kept 50 kg of cut grass in the sun for several days. The dried grass weighed 15 kg. Then he kept this grass in a warm oven for a few hours. Now it weighed 7 kg. Why did the weight change? How much water did the fresh grass have?

Classroom experience

Some students thought the grass might have got burnt in the oven. I explained that the oven was only warm enough for the remaining water to evaporate from the grass. Fifty kilograms of grass had 43 kg of water in it.

2. Find out your own weight. About two-thirds of the weight of your body is due to the water in it. Now estimate the weight of the water in your body.

Conceptual problem

This problem was a little difficult because of proportional reasoning and the calculation involving fractions. I explained fractional quantities giving the example of peanuts and

jaggery used in different proportions to make *chikki*. Then I drew the outline of a human on the board and divided it into three parts. For a person weighing 30 kg, students guessed that the weight of water in the body would be 20 kg. Likewise they handled other multiples of 3. Most of their other answers were at least roughly accurate: I think they finally did learn something from this exercise.

Show and tell

1. Bring something that is not living but needs water to work properly. Show it to the class and tell about it.

Students might bring some kind of pump (like an ink-dropper), a tap, a tea filter, or even things like a glass (it won't give you a drink unless there's water in it!), or plaster, lime, and cement powder (they can't be used until you add water), various food items, like atta, rice, or tea leaves, which need water in order to be cooked.

Ask a question (WB p. 101)

1. Ask questions related to water and living things. Think of how you will try to find out the answers.

Students' questions

Can river fish live in the sea?

> Normally fresh water living things cannot survive in salt water - they get dehydrated - and salt water living things cannot survive in fresh water - they tend to take water into their cells due to osmosis. Some exceptional fish like eel and salmon can move between salt and fresh water - they live in the sea but breed in the river. On the way these fish often remain in the brackish river estuary for some time to acclimatise themselves to the changing environment.

DID YOU KNOW? (TB p. 64)

Frogs and ducks take a deep breath before they dive down into the water for food.

All amphibians and birds absorb oxygen through their lungs. Amphibians can in addition exchange gases with the surrounding water through their skin and their mouth cavity.

Fish use oxygen dissolved in water. Water with oxygen enters their mouth and comes out over the gills. Oxygen passes through the gills of the fish into its blood. Carbon dioxide comes out of the blood and dissolves in the surrounding water.

Fish absorb oxygen from the water into blood capillaries in their gills. The blood vessels in the gills are so close to the surface they are practically in contact with the outside water. Oxygen from the water easily passes into the fish's blood. We cannot breathe in water because, unlike gills of fish, our lungs cannot separate air from water.

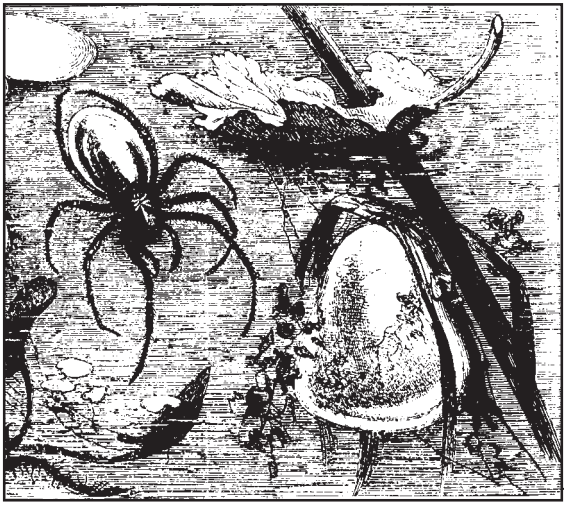
Water contains much (30-40 times) less oxygen than air does. This small amount of oxygen has to be absorbed efficiently by the fish. To do this, the gills of the fish have many folds with a large network of thin blood capillaries on their surface. The blood in the gills flows in a direction opposite to the flow of water, resulting in a higher concentration of oxygen in the water everywhere outside the gills than in the blood inside. As a result, fishes can absorb up to 80% of the oxygen passing over their gills; in comparison, we absorb only about 25% of the oxygen going into our lungs (see pages 124-125, Chapter 4).

Lungfish, which live in shallow and stagnant waters, come near the surface to gulp air. This air goes into lung-like organs where the oxygen passes into the blood and carbon dioxide passes out.

All parts of a plant, including the roots, need to breathe. Mangroves are trees that grow in wetlands. Their roots come up above the water to breathe.

All wetland plants have some mechanism to provide air to their roots which are submerged in water. In reeds, lotus and water lily air is transported via the stem to the roots through a system of tubes (aerenchyma). Plants which are completely submerged in water store the oxygen that they produce during photosynthesis in spaces inside their bodies and use the same for respiration.

The water spider lives in ponds. It spins a cobweb like a sheet of silk at the bottom of the pond. Then it swims up to the surface and flips its hind legs to make an air bubble. It carries the bubble down and releases it below the cobweb. It keeps diving up and down, each time bringing a little air to fill its house. It goes out of the house only to catch its food.



The water spider does not use its web to catch food. When the air in the web becomes stale with too much carbon dioxide, it builds another web.

CHAPTER 7

Water and us

ACTIVITIES

Water is precious!

1. Where did this water come from? (2 periods; TB p. 65, WB p. 102)

a. List the places where you have seen water. For every place you listed ask yourself, "Where did this water come from?". When you do not know the answer, ask someone else (WorkBook page 102).

Students' responses

Students had listed some places during classroom discussion at the beginning of the Unit. Other examples came up later. Incidentally, they had noticed that water in different towns and from different sources tastes different, and connected this to the fact that water flows over rocks and soil which differ according to regions and that water is a good solvent.

Places I have seen water	Where this water came from
a glass	the water jug
the water jug	the tap
the tap	water pipes underground
water pipes	a tubewell

The important fact to realise is that ultimately we have only ONE source of fresh water: the rain (or snow in some areas). Still, students found it difficult to go back several steps to the source of the water. The next activity helped them.

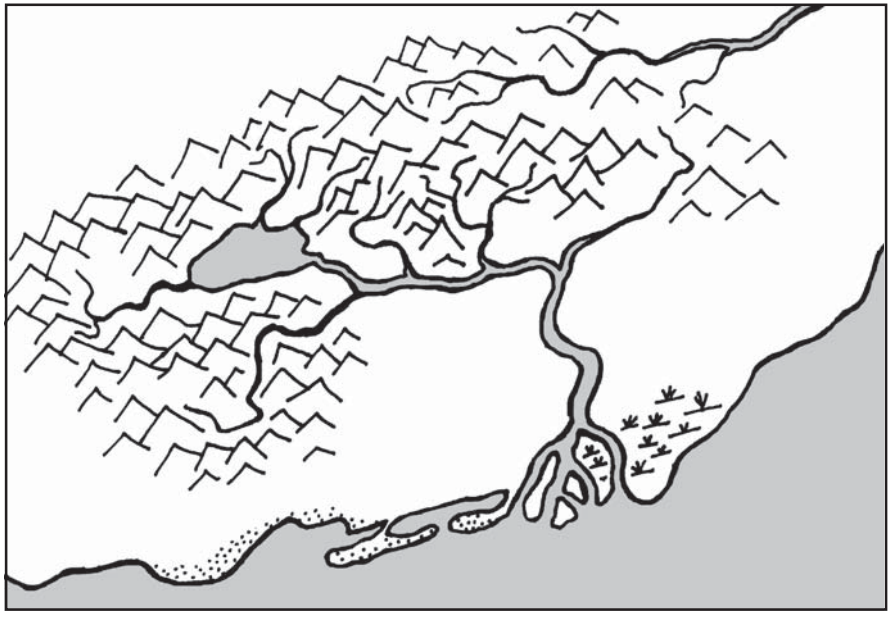
b. Water falls as rain. It travels a long way to come to your home. Your teacher will explain this. Describe how the rain water comes to your home, so that you can drink it (WorkBook page 102). Draw a picture to show this on page 108 in your WorkBook.

Teacher's task

The teacher must find out about the surrounding sources of water supply in order to explain water sources with reference to the local situation. The major source of water in the area might be a river, a lake, surface well or borewell. There might be community tanks or other storage tanks maintained by the local civic bodies. The water in all of these comes directly or indirectly from the rain.

There is about 10^9 cubic kilometers of water on earth. Of this, 97.2% is in the oceans and 2.0% is frozen in the ice caps. Only about 0.63% of the water on earth is fresh water that we can use.

When water falls as rain some of it evaporates from the ground or is taken up by plants and then let out into the atmosphere through the leaves. Part of the rain water (or melted snow) goes directly into streams, rivers, lakes, tanks and other surface sources. But most of the rain water percolates into the ground and is useful for providing water throughout the year to wells, tubewells, percolation tanks and also (from under the ground) to streams, rivers and lakes. If it were not for this ground water all streams and rivers would dry up after the rainy season. (See student's questions on pages 244-245)



Classroom experience

Since these students live in Mumbai I told them about the lakes - Vihar, Tulsi, Tansa and Vaitarna, from which we got drinking water. The lakes are situated in the Sahyadri hills. When it rains in the hills the water flows down in streams and is collected in the lakes from where it is brought down through a system of pipes into storage and purification tanks. I told them about the large storage tank beneath the Hanging Gardens where many of them had gone on picnics. Finally the water comes through pipes to their own homes where it is pumped into tanks.

Neither the students nor I were sure where the water in the sea came from. The earth was formed as a hot ball about 4.6 billion years ago and the water on it was produced out of complex physical and chemical reactions. Initially all the water was in the form of vapour but as the earth cooled, it fell as rain to make oceans.

2. How we use water (homework + 1 period; TB p. 65, WB p. 103)

Answer these questions for yourself. Then ask your parents, grandparents or other older people, how they did these things when they were as young as you are (WorkBook pages 103-104):

How did you clean your teeth? (*datun*, toothpaste and brush ...)

Where did you bathe? (at the river, tank, home ...)

With what did you clean your body? (*besan*, soap ...)

How did you wash your hair? (*shikakai*, shampoo ...)

Your source of water (river, common well, house well, common tap, tap at home ...)

Was the water source inside the house or outside? How far away?

Who collected the water?

Where were the clothes washed?

With what were the clothes washed? (soda, bar soap, detergent ...)

What kind of toilets did you use? (outdoors, dry latrine, flush toilet ...)

Where did you bathe? (at the river, tank, home ...)

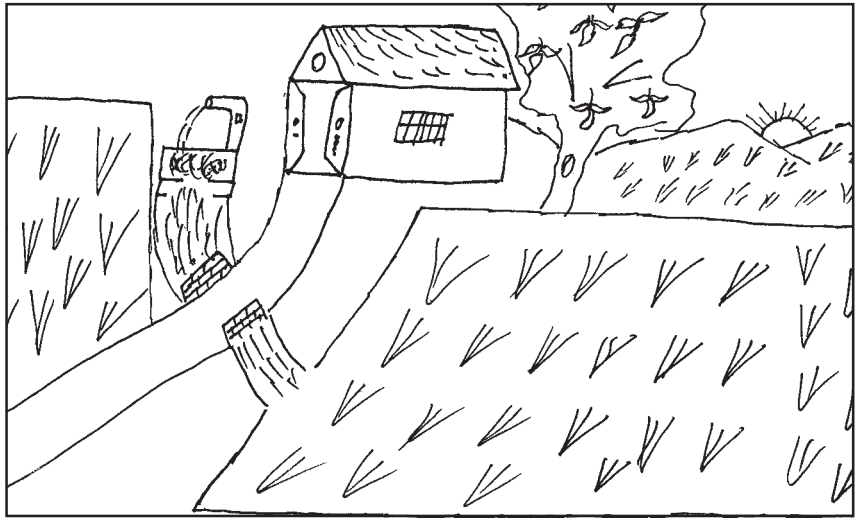
Classroom experience

Students completed the worksheet by consulting their parents, grandparents and other elders. Some parents could recall how things were in the grandparents' time. We collected these experiences during classroom discussion. Students who were unable to find the information on their own completed their WorkBook Table after the discussion.

3. Water for crops (1 period + field trip; TB p. 66, WB p. 104)

Find out how crops are watered in the area where you live. Is rain water sufficient? Is water brought to the fields in other ways? How? Which crops can do with less water and which need more? (WorkBook page 104)

Explain what is happening in this picture:



Classroom experience

Students in rural areas would answer these questions easily while urban students would have to be told about common methods of irrigation used in the surrounding areas. There might be dams and irrigation canals nearby. When some more information on agriculture is given (in Chapter 8) a field trip would be useful. The picture on page 224 shows water being pumped from a tubewell into a field.

> Water needs of any particular crop depend partly on climactic conditions, quality of soil and drainage. Clayey soil gets easily waterlogged but also dries easily due to capillary action. Sandy soil drains away water quickly. Soil with more organic matter is best for crops because it remains porous and also holds water over a long time.
> Bajra and ragi are rain-fed crops. They need less water and can therefore also grow in sandy, poor quality soil. Some crops which need a lot of water are, rice, sugarcane and banana. Rice and sugarcane are wetland crops in the wild, cultivated with the help of irrigation.
> For many crops it is possible to minimise expenditure of water by using an appropriate method of irrigation. The famous drip irrigation used in Israel is a way of providing water in controlled quantities to the roots of plants - just where it is needed.

4. Measuring water (homework + 2 periods; TB p. 66, WB p. 104)

a. Look for jars, bottles, packets, cans or tanks that show how much liquid is stored in them. The amount of a liquid is called its **volume**.

We measure volume in litres (l) and millilitres (ml).

1000 ml = 1 l

Classroom experience

Students did the Activity at home. I found that one boy in the class had gone about the task very methodically - he had listed about 25 containers in increasing order of capacities - 5ml. and 10 ml. marked on medicine cups, medicine bottles of around 50 ml., hair oil etc.

of around 100 ml., cold drinks of around 300 ml., milk packet, cooking oil, wall paint of 1 l., larger cans of motor oil etc. of 2 l. and 5 l., pressure cooker 5 1/2 l. bucket 15 l., drum 70 l. and Sintex tank 400 l.. I used his list to make the other students think about the magnitudes of the numbers that they had written (smallest, largest, how many of one would fit into the other, etc.). They also did some guessing and estimation - eg. how much water would fit into this pot/ can, how much water do we need to gargle, to wash vegetables, etc.

b. Find a container that can hold a little more than 1 litre. Your teacher will pour exactly 1 litre of water in your container. Stick a piece of cellotape to show the level of water (WorkBook page 105).

Practical hints

I prepared for the activity by using a measuring cylinder to get an idea of the capacities of some commercially available containers.

Container	Marked capacity	Measured capacity
Large Pepsi	1.5 litres	1590 ml
Bisleri water	1 litre	1050 ml
Bailley water	1 litre	1040 ml
Thums Up	300 ml	320 ml
Soda	250 ml	

Students were asked to bring a one litre container. Since many of them were not able to locate one easily, they brought containers of other sizes. To handle this situation I standardised three wide mouthed containers to measure 1000 ml., 500 ml. and 250ml.. After pouring a known amount of water in the student's container I marked the level with indelible ink. One could also use oil paint, fevicol, transparency marker, strong cellotape or masking tape.

We expressed the quantities in litre and millilitres. Students had not yet learnt fractional decimal notation, but after reading the packaging information, some of them started writing, say, 1 l 350 ml as 1.350 l, and I let it be at that.

5. How much water do we need? (2 periods + homework; TB p. 66)

a. Guess how much water is needed to grow 1 kilogram of rice. Check your guess with your teacher. Does all this water remain in the rice plant? Where do you think it goes?

> Chapter 8 of the TextBook shows the stages of rice cultivation. Rice plants need a lot of water during the early part of their growth. To grow 1 kg. of rice we need approximately 4500 litres of water! Other plants like wheat and corn need about one-third as much water. Of the part of this water taken up by the plant only about 1% is used up in the plant's growth, 99% is given back to the atmosphere, mainly through transpiration.

b. Guess how much water you need to take a bath. Check your guess using your marked container (WorkBook page 105).

Classroom experience

Students' guesses for how much water they needed to take a bath ranged from 4 l. to 30 l., which they checked later at home.

Incidentally we discussed here why it was important to have a bath. Students said it was to feel cool and fresh, stay clean. Why did we need to keep our body clean and wear clean clothes? "To look smart", "to smell good", "to be liked by everyone", were some of the responses. I explained that having a bath was not just for good looks or a troublesome rule imposed by parents. Bad body odour shows that microbes are multiplying on your skin. Dust contains small living things that can cause fungal or bacterial skin diseases, or scabies which is caused by a tiny mite that burrows under the skin. Having a bath is important for staying healthy. Only in extremely cold or extremely hot and dry weather a daily bath may not be necessary.

c. List the ways in which your family uses water every day. Estimate how much water your family uses for these different things. In your Workbook on page 105 write your guess in litres (l) and millilitres (ml).

Students' responses

Daily uses of water listed by (urban) students: brushing teeth, toilet (urine and stools), washing legs, bathing; washing clothes, utensils, floor, cleaning windows; drinking, cooking vegetables, making tea, doing *pooja*; watering plants, mixing cement etc.

Classroom experience

For some of the uses in 5c. students first gave estimates in terms of pots or buckets and then converted them into litres and ml..

Aim of the activities

Activities 6-8 deal with water pollution and how to get clean water. These activities should prepare the background for understanding the effect of polluted water on our health - a topic to be done in more detail in Class 5.

6. How clean is the water? (1 period; TB p. 67, WB p. 106)

Collect a glass of water from at least two different places near your home or school.

a. What is the colour of the water?

b. Is the water clear or turbid?

c. Are there any things floating in it?

d. Does the water have a smell? If yes, describe the smell.

e. Let the water stand in a glass. Does anything settle to the bottom?

f. Filter the water through a piece of cloth. Does anything remain on the cloth?

g. Add soap powder to the water. Stir it briskly. Is there any lather?

h. Pour some of the water in a dish. See what is left after it evaporates (WorkBook p. 106).

Classroom experience

We used two kinds of water: tap water and water from the nullah.

Tap water from the municipality: Clear with no floating matter, it had a faint smell of chlorine, when kept standing nothing settled to the bottom, there was no residue on filtering, it lathered easily and after evaporation left a fine white residue.

Water from the nullah: Whitish, turbid, faint but not unpleasant smell, some mud settled but remained turbid on decanting and filtering, gave less lather with soap, left a brown-white residue on evaporation.

7. How to get clean water (2 periods; TB p. 67)

a. Keep some dirty water in a glass. Check if any dirt settles down. Carefully pour out the water from the top. This way of cleaning water is called **decantation**.

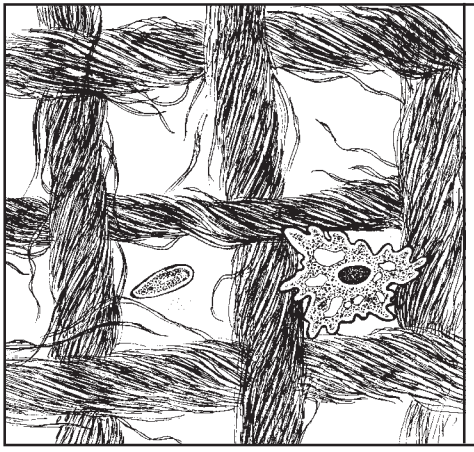
Is the decanted water clean? In which ways could you use it? (WorkBook page 106)

Would you drink this decanted water? Why or why not?

Is there any way that you can make the dirt settle faster? Find out from your parents or teachers.

Classroom experience

I had introduced the term 'decantation' while filling the WorkBook table for Activity 6e. Decantation removes some of the impurities. A piece of alum if moved through the water helps the dirt settle quickly. Alum also kills some microbes. Like alum, dried and powdered seeds of drumstick (*Moringa oleifera*) act as coagulant, helping the dirt to settle.

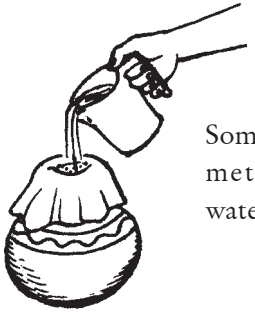


b. Filter this water through a cotton cloth.

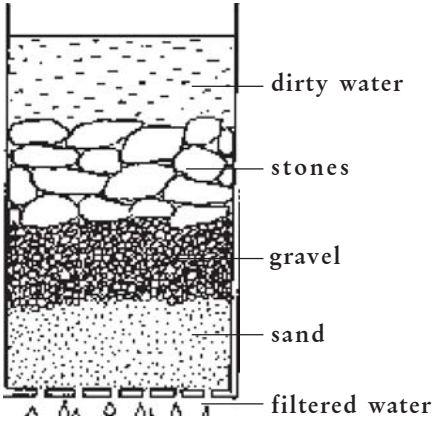
The picture on the left shows what a cloth looks like through a microscope. In this picture there are also some microbes like the ones on page 60 in the TextBook.

Do you think water that is filtered through this cloth will be clean? Do you think microbes can pass through the cloth? Would you drink it? Why or why not? (WorkBook page 106)

Filtration removes those floating impurities which are larger than the holes in the filter. Folding the cloth into several layers would make a more effective filter, but the above picture shows that most microscopic living things could pass through ordinary cloth. Filtration through activated charcoal is more effective as even smaller impurities and some dissolved gases stick to the charcoal. But ordinary filtered water is not safe to drink as it would still contain microbes.



Some simple classroom methods of filtering water are shown here.



8. Water for drinking (1 period; TB p. 68, WB p. 107)

Sometimes water may look clean but it may have microbes that are too small to see.

Most kinds of microbes are not harmful to you. But just a few dangerous microbes in your water or food, or in the water droplets you breathe, might make you sick. Some dangerous microbes are shown on page 60. Name some illnesses they could give you.

If you boil water and keep it boiling for 20 minutes most of the microbes will be killed.

Store drinking water in a clean, covered container.

Do not let water stay in puddles or open tanks. Mosquitoes and sand flies lay their eggs in stagnant water. These insects spread diseases.

Never do these things near a source of drinking water:

Washing clothes and utensils	Bathing	Defecating
Letting out waste from factories	Washing cattle	

In Chapter 6 students have been introduced to a few water-borne microbes which cause diarrhoeal diseases. These microbes usually enter the water through contact with sewage. Eggs of roundworm, tapeworm etc. may also enter in the same way. By drinking water contaminated with sewage we can get diarrohea, dysentry, amoebiosis, cholera, typhoid and various parasitic / worm infections of the digestive system. See Chapter 10 (page 327) for brief information on diarrhoeal diseases.

Other harmful pollutants might be chemicals - mercury, lead or arsenic compounds or any of a number of poisonous organic chemicals. These may come from natural sources but most often they are the result of human activities

like manufacturing and farming (fertilisers, pesticides and herbicides - see Chapter 8 (pages 278-279 and 286)). Large sources of water supply are disinfected using chlorine, bleaching powder or potassium permanganate. The disinfectants destroy microbes but cannnot remove non-living pollutants!

9. Save water! (4 periods)

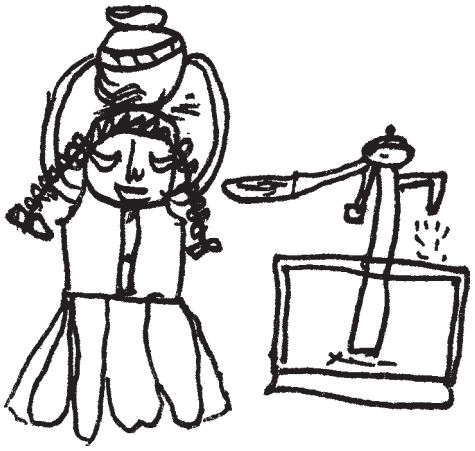
a. Think of different ways that you could save water in your home, school and neighbourhood (WorkBook page 107).

Students' responses

Many ways were suggested like, pouring only enough to drink, not letting tap or pump water flow off, having a bath from a bucket instead of a shower, and planting trees. The *Name and Draw* posters on saving water were made.

b. Have you ever seen water being wasted? Find out if there is a leaking tap or pipe nearby. Collect this dripping water. Measure the time and the amount of water collected. Estimate how much water is wasted from the tap in one day. Do something to stop the waste.

Do not keep tap or pump water running needlessly. Turn off the tap while you brush your teeth or bathe.



Classroom experience

There was fortunately no leakage found in the school, though students had seen leaking taps often. We kept the tap of the water tank dripping just a few drops a minute to make this measurement.

In ten minutes we had collected 300 ml water. Students calculated that in one hour 1800 ml of water would be wasted, and in 24 hours 43200 ml or more than 43 litres of water would have been wasted! So much water might have been used by perhaps four people to bathe.

> If there is stagnant water around us we can get (from Anopheles mosquitoes) malaria, (from Culex mosquitoes) filaria and Japanese encephalitis; (from sandflies) kala azhar. These deadly and persistent diseases can be completely eradicated by not allowing puddles and open drains, and keeping overhead tanks in buildings well covered.

c. Think of ways to collect and use rain water.

Plant trees. They help to save water.

Classroom experience

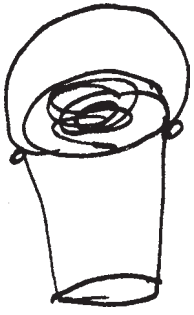
Unfortunately where there is a public supply of water, people have stopped thinking about ways to conserve and use rain water. For students in my class it was a completely new ideas. I told them that in a few places, in villages as well as large cities, people faced with water shortages have started harvesting rain water, from rooftops as well as by letting it sink into the ground.

> Good water management consists of preventing rain water from running off, so that there is enough water for use throughout the year. Traditionally people in India have developed many techniques to store, transport and use rain water. As stated in the *Did you know* section, these techniques have enabled people to live in areas with annual rainfall as low as 10 cm, while Cherrapunji with an annual rainfall of more than 1000 cm is officially recorded as suffering chronic water shortage.

Supplies of ground water too need to be continuously recharged. Ponds and percolation tanks help, and so do plants. Any vegetation, whether shurbs, grass, cultivated crops or a forest, helps to mimimise the impact of rain on the land and to check the flow of water. The roots hold soil together, at the same time keeping it loose and allowing water to sink inside. The decaying organic matter or humus produced by plants prevents soil from flowing off, letting water seep in and be stored as ground water.

Rain water collected in small quantities should be used immediately so that it does not create stagnant pools. In bigger tanks one can breed fish like guppies to keep mosquitoes and sandflies in check. Such community efforts might exist in your area.

10 litres



10 litres

Know these words

pond	well	dam	marsh
lake	pump	canal	stagnant
spring	tubewell	irrigation	

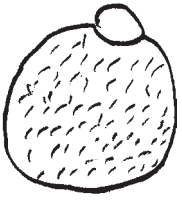
EXERCISES (12 periods + homework; WB p. 107)

Name and draw

1. Containers used to store water at your home or school. Guess the capacity of these containers. Check your guess if possible.

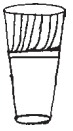
1.2 litres

9 litres



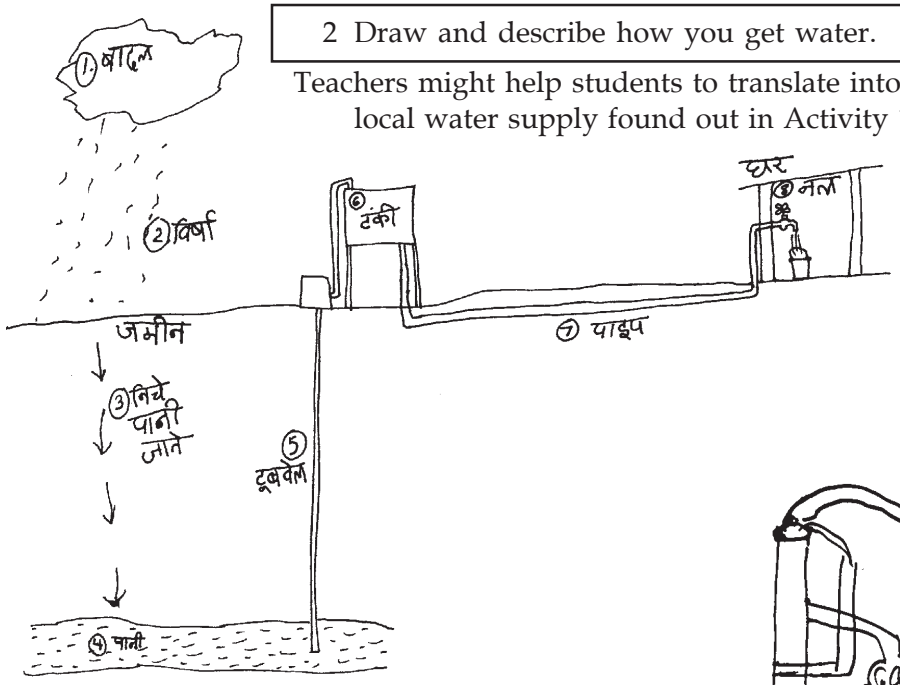
1800 ml

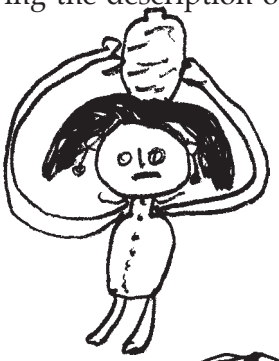
250 ml

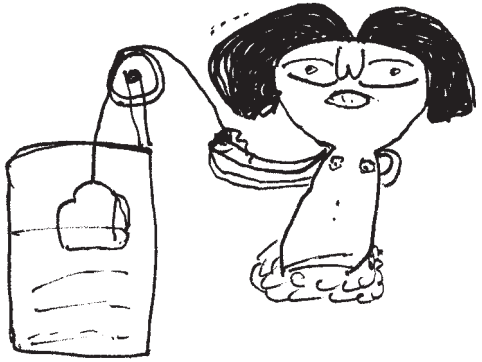


2 Draw and describe how you get water.

Teachers might help students to translate into drawing the description of the local water supply found out in Activity 1b.







3. Make a poster showing in what ways you can save water.

Done with Activity 9.

Interesting questions (WB p. 109)

1. Does the water you drink at home come from a well, river, lake or somewhere else?
2. Write these sources of water from smallest to largest:

   lake ocean dewdrop pond puddle sea

dewdrop puddle pond lake sea ocean

3. Name three different ways of drawing water out from a well.

Bucket on rope, pulley, water wheels, animal power, hand pump, diesel and electric pumps

4. Which of the following needs the cleanest water? For which uses can you have water that is not so clean?

   drinking watering plants bathing washing floor

For drinking we need the cleanest water with the least number of microbes and other contaminants (though small amounts of some minerals might be harmless or useful). Water for bathing could be less pure. Plants might be watered with dirty water although some chemical contaminants like factory wastes are harmful for plants as well as for us. For washing the floor too one need not use very clean water.

5. About how many litres of water do you drink every day?

Classroom experience

In Class 3 students had counted the number of glasses of water they drank in a day. Now they had learnt that a medium-sized glass held about 200 ml. of water and could answer the question by counting and some estimation. We need to drink about 1 1/2 litres of water daily.

6. About how many millilitres of water do you need to brush your teeth?

Done with Activity 5d.

7. In what different ways is water used in the kitchen?

Washing, soaking, mixing, boiling and steaming are obvious responses. Even frying, roasting, baking and popping grain, which do not use water directly, are possible only because there is water inside foods.

Classroom discussion (WB p. 110)

1. Do you get clean drinking water near your home? Do all the people in your village or locality get water easily? What problems do people have in getting clean water? How can these problems be solved?

While for some children water shortage might be a part of life, others perhaps living in in well-to-do areas of cities might not be aware of these problems. Observing the facilities in surrounding areas and discussing with adults would be helpful.

2. Do you ever carry water from one place to another? Why do you have to do this?

Responses would vary according to the region. In many schools too clean drinking water is not available. Students might also have carried water while travelling.

3. Do one or more persons in your house get water for the whole family? Do they make sure that there is clean drinking water for all? Who does this work and why doesn't someone else do it?

This work is important yet often taken for granted. It is usually done by women and girls in the household.

4. Is your drinking water decanted? Is it filtered? Who decants and filters it? Where? What are the different ways of filtering water?

The teacher would have to help in obtaining this information locally. General information can be found in Civics textbooks under functions of local governments.

What's the same? What's different? (WB p. 110)

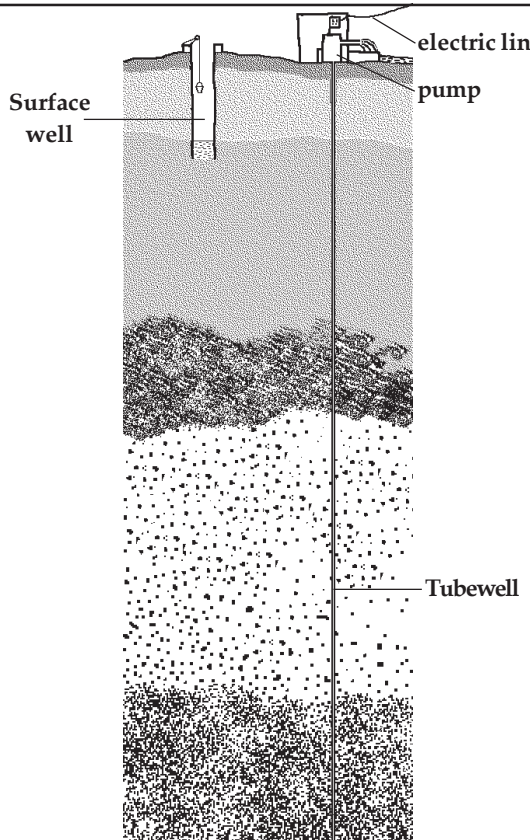
1. Give two similarities and two differences between:

a. A tank and a river

Both are sources of water. Their water is usually not salty. A river is natural, has no walls (unless we build ghats, bunds and dams). A tank is built by people. Water in a river flows, in a tank it is still.

b. A well and a tubewell

Both are dug by people to get water from under the ground; a well (also called surface well) is less deep - about 5-10 metres while a tubewell (also called borewell) could be 100 metres or deeper; a well is wider than a tubewell which is usually a pipe about 10 cms. wide; tubewell being deeper, a pump is needed to draw water out of it.



2. Find the odd one out:

a. pipe, canal, well, stream

b. sea, tank, river, ocean

c. ocean, creek, lake, sea

Some possible answers:

a. A well, because its water does not flow
b. A tank, because it is made by people
c. A creek, because its water is flowing down

Talk and write (WB p. 110)

1. When we had no water

Student's writing: "Every morning we get water in the tap. But one day a big pipe broke near our house. There was water on the road but no water at home. I did not have a bath for three days. We walked to the well to get water."

Ask and find out (WB p. 112)

1. How is rain water stored for use by your village, town or city? Most big cities are situated on the banks of a river, or close to a large lake. Find the names of some cities and the rivers or lakes they are on.

Students should look in maps to find the answer to this question. A few major Indian cities and pilgrimage centres on major rivers are listed on the next page. More examples could be found locally. Students might have also heard about ancient civilizations founded on the banks of rivers, and many modern cities situated on well-known rivers all over the world.

Some Indian cities on banks of rivers:

Yamuna - Delhi, Mathura, Agra, Allahabad

Ganga - Hrishikesh, Hardwar, Kanpur, Allahabad (on the *Sangam*), Varanasi, Patna, Bhagalpur

Hoogly - Calcutta, Haldia

Narmada - Jabalpur, Hoshangabad, Bharuch

Tapti - Bhusaval, Surat

Sabarmati - Ahmedabad;

Mahanadi - Cuttack

Godavari - Panchavati, Nanded, Bhadrachalam, Rajahmundry

Krishna - Sangli, Satara, Srisailam, Kurnool, Vijaywada

Cauvery - Mysore, Srirangapatnam, Kumbakonam, Thiruchirapalli

Some Indian cities on the banks of lakes:

Dal Lake - Srinagar

Lakes Pichola, Fateh Sagar and **Udai Sagar** - Udaipur

Bada Talab and **Chhota Talab** - Bhopal

Lake Chilika - Bhubaneshwar

2. Many years ago did your village, town or city use the same water sources that you do now? What were their sources of water?
3. Find old sources of water like wells and tanks in your locality. Find out whether and why these sources are not used any more.

In many areas as the population has grown, new sources of water have been found and old ones often given up. In cities one can find old wells and tanks which might have got contaminated due to misuse. Many old water management systems were ingeniously constructed taking account of the geography of the area. There might be local examples of

very good water management practices. On the other hand there are examples all over the country where the neglect of traditional sources and mismanagement of new ones has led to severe drought situations.

4. Can we prevent floods and droughts? How?

Classroom experience

In Chapter 1 (page 52) we had discussed ways of preventing floods. Many of these ways involved directing flood water to places where it could be stored for use in dry times besides raising the water table, avoiding indiscriminate cutting of trees and planting more trees. The same actions are useful in preventing drought.

The city students in my class accepted a limited availablity of water as the status quo. They knew of water shortage in summer, but no times of severe drought. They had however heard of droughts in other places. I told them that if there were good arrangements for storing and transporting water, droughts and water shortages would be rare in cities. However, most places in our country do experience water shortage. Thus in many cities water is supplied only at certain times, which may only occur once in 5 or more days. Better water management, improved planning and building of water reservoirs for cities and rural areas is badly needed.

Figure it out (WB p. 112)

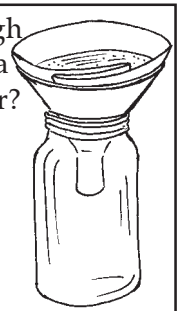
1. Ninety seven percent of the water on the earth is in the seas and oceans. The water you drink might have been in the ocean at some time! At that time there was salt dissolved in it. How did the salt get separated from this water?

Classroom experience

Students were not very familiar with percentages but even after I explained this part they continued to be puzzled by the question. Although they knew the water cycle well, they

did not immediately connect it with this question. Some rushed to say that if sea water was filtered the salt would be separated. Others thought of machines to separate water from salt (desalination plants based on either evaporation or 'reverse osmosis' are used in some Arab countries though they are very expensive). Only after several hints students guessed I was referring to evaporation by the sun's heat. Some tribes in Mexico and Africa use evaporation followed by condensation to get drinking water from saline water.

2. Water can pass through blotting paper. Sand cannot pass through blotting paper. Mini made a cone of blotting paper, rested it on a funnel and poured sandy water into it. What came out in the jar?



   a. Sand only
   b. Water only
   c. Sand and water
   d. Nothing

3. Every morning Apu filled a pot with clean drinking water. Some mornings he noticed that the family had finished almost all the water in the pot. Other mornings there was more water left. One week he counted the number of dippers of water left in the pot each morning and made a graph.

a. How many dippers of water did he find on 3 May? On 5 May?

3 and 5 dippers

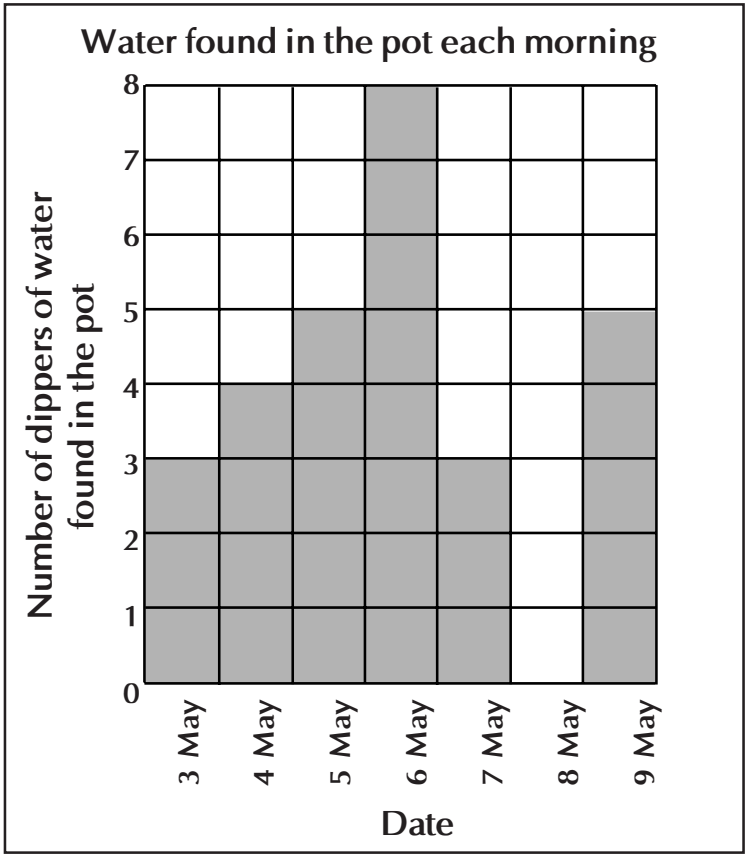
b. On one of the days they had visitors. Guess which day this was.

7 May

c. On one of the days they were out all day at the fair. Guess which day this was.

5 May

While question 3a was easy, in 3b and 3c students had to realise that the water found on any morning gave information about the usage on the previous day. This inference was difficult for many students. In the rain graph in Chapter 1 (*Figure it out* no.4) too the measurement of water height on any day gave information about the previous day, but there the questions had been simplified by asking only how much water was **found** on a particular day.



Show and tell (WB p. 113)

1. Bring a newspaper or magazine article on problems of water supply. Explain it to the class.

Ask a question (WB p. 114)

1. Ask questions about how we use water. Think of how you will try to find the answers.

Students' questions

Why is sea water salty?

Students' responses

Students had heard a number of stories (which they half-believed) about how the sea water came to be salty. There were stories from mythology, one about a mill under the ocean which keeps producing and grinding salt, and a ship which sank while carrying salt. One student objected that there was many times more than just one shipful of salt in the sea. Another student had heard that streams and rivers dissolve salt in the rocks and soil and carry it to the sea. But then the question came up, why is sea water so much saltier than river water?

> Water in rain-fed rivers might have fallen as rain during the last year or so. Every year the rivers bring a little salt to the ocean. Scientists used to believe that this continuous accumulation of salt coupled with constant evaporation makes the oceans get saltier all the time. However they later found evidence to show that the saltiness of the oceans has been fairly constant since about 2 to 1.5 billion years ago. Currently scientists believe that the salt in the ocean arose between 3.5 to 2 billion years ago, as as a result of acids reacting with rocks. As for the salt that is carried into the oceans by streams every year, an equal amount is deposited on the ocean floor keeping the saltiness of the water constant.

Where do rivers get water from during the dry season?

> The previous discussion brought up this new question. Our rainy season extends over at most three or four months in the year. During the remaining months there is still water in the larger rivers constantly flowing down to the sea. Where does this continuous supply of water come from?

The water in rain-fed rivers in the dry season is actually ground water which has seeped down during the rains. During the dry season it slowly comes up by capillary action. Long after the rains are gone this water is used by plants, some evaporates and some flows into streams and rivers. The snow-fed rivers of Northern India get water in summer from the melting Himalayan snow.

How do people dig wells so deep and how do they come back?

DID YOU KNOW?

If we store water, share it and use it carefully there will be enough water for everyone.

Traditionally people in India have found many ways to store, transport and use rain water. In the Indus valley civilisation (3000 - 1500 BC) people built dams and dug wells and canals.

Some parts of the Rajasthan desert get only 10 cm of rain every year. Here people store rain water and use it throughout the year.

But what if we do not store water . . . ?

Cherrapunji is a very rainy village in the hills of Meghalaya. Here it rains about 1140 cm every year! Yet Cherrapunji suffers water shortage, because the water runs off the mountain slopes and is not stored for use.

SUPPLEMENTARY QUESTIONS

1. Name something that might float in water if you put it in one way, but will sink if you turn it around another way.

2. How could you compare how much water condenses on three tumblers made of glass, metal and plastic?

3. How could you find out which of two apples has more water in it?

4. How could you find out where water goes when a wet shirt dries?

5. Which of the following things has water in it? Tell whether each thing has a little, a lot, or no water:

cabbage, a wooden table, a marble, a mango, cotton cloth, a raw potato, a cockroach, a hair

6. It is better to use water from a well dug near pond or a river rather than from the pond or river directly. Why could that be?

(Water in the pond or river might be dirty. Well water has been naturally filtered through layers of soil. However if dirty water is allowed to seep through the ground close to a surface well it will contaminate the well water. Water from a borewell comes from deeper layers and so is cleaner.)

7. Does water from different sources taste different? Why?

(Yes, due to dissolved substances.)

UNIT 4

FOOD

Chapter 8 Where our food comes from

Chapter 9 Food in our body

Chapter 10 What is thrown out

UNIT 4 FOOD

AN OVERVIEW

Objective **To learn about the origin of food, its transformation in the body and the disposal of our food wastes.**

4.1 To enquire about different foods: their origin in plants and animals
  a. Some food plants and their edible parts
  b. Animals as sources of food
  c. Food requirements of domestic animals
4.2 To learn about locally-grown food crops
4.3 To get an idea about the different stages of rice cultivation
4.4 To carry out some steps in growing and processing foods
4.5 To observe some plant pests in the home and outside, to be aware of some uses and dangers of pesticides and to consider alternative methods of crop and grain protection
4.6 To be aware of some uses and dangers of chemical fertilisers and the alternatives available
4.7 To examine our own food consumption and to avoid wasteful practices, to realise that in the midst of plentiful food there is still starvation for many
4.8 To understand the basic structure of our digestive system (without necessary reference to auxilliary organs)
4.9 To know of the transformation and absorption of food inside the body (an idea of physical and chemical transformation, as well as time-scale, to be conveyed through experiences)
4.10 To realise that digestion of food is common to all animals

4.11 To be aware of the considerable amount of food wastes produced by humans and to ask how these wastes are disposed
4.12 To be aware of the role of other animals in consuming our wastes
4.13 To be aware of microbial decomposition of plant and animal matter
4.14 To be aware of dangers of microbes as well as their crucial role in recycling natural resources
4.15 To find out about methods of sewage disposal, to know that improper disposal of garbage and sewage poses danger to our health and survival
4.16 To question practices harmful to us and to our environment

What is new in this Unit

One aim of *Small Science* is to convey the idea of natural resources by examining one's own use of these resources. For everything which we use in our lives we ask, "Where did this thing come from?" and "Where will it finally go to?" This approach is illustrated in the Unit on Food.

The Unit uses enquiry into everyday life and attractive pictures to combine several normally disparate, perhaps often tedious topics like, agriculture, uses of plants and animals, food safety, preservation, fermentation, digestion, garbage and sewage disposal, natural resources and renewability.

Chapter 8 introduces food production, a topic which might be part of everyday life for rural students but entirely unfamiliar to urban students. All students however should gain from the observation, analysis and expression required in working through this Chapter.

The structure of the digestive system in introduced in Chapter 9. In digestion, food is broken down into small particles partly physically, but more importantly by chemical processes. Chapter 9 should give students an intuitive idea of chemical processes and of how such transformations might be taking place in the body.

Chapter 10 focuses on the things that we throw away - the garbage produced at various points in processing foods and finally the household sewage. Important here is the idea of microbial activity leading to decomposition of waste materials. In Chapter 4 we noticed

that rotting (decomposition) is associated with smells and gases. We were also introduced to microbes in the air and in water. Now we learn that microbes are responsible for decomposition (breaking down). Decomposition might be a nuisance in the short term, but ultimately it is a crucially important process which recycles nutrients from dead to living matter again.

The Unit should lead students to an awareness of hygienically and ecologically sound practices. Somewhat more than in the first three Units, the questions here are expected to involve adults in the surroundings: giving students a chance to learn from the adults' experience, while providing a context to address health-related and environmental, as well as some social and political issues.

Time-table

P: Number of periods

Chapter 8

P1-P16 - Activities

P17-P28 - Exercises

Chapter 9

P29-P41 - Activities

P42-P51 - Exercises

Chapter 10

P52-P68 - Activities

P69-P76 - Exercises

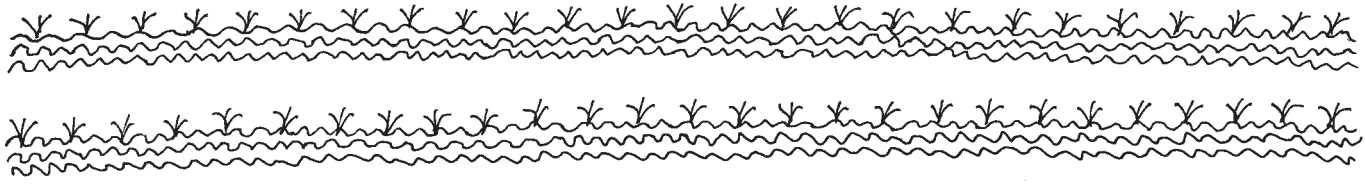
Some exercises are to be done along with activities and as home-work.

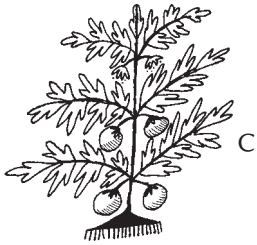
Materials and information to be collected for the Unit

Chapter 8: Different foods, grains and seeds including rice and vegetable seeds; tray or pots for indoor planting; space and tools for outdoor planting; flat and round stones for grinding, bottle caps for measuring; samples of grains and vegetables/ plants infested by pests; information about crops grown locally or nearby, about farmings activities, sowing and harvesting seasons and tools used.

Chapter 9: Small quantities of foods for starch testing; used plastic bags eg. empty milk pouches; cellotape, stapler or needle and thread, ripe bananas; cotton cloth about 20 cm square per group; plates and spoons; rope about 7m long, marking pen.

Chapter 10: Small quantities of foods for decomposition; four banana peels and four pots or outdoor space; information about garbage and sewage disposal in the locality, about garbage and sewage treatment if existing.





CHAPTER 8

Where our food comes from

ACTIVITIES

Find out about food

1. Where does food come from? (1 period + home-work; TB p. 75)

Yesterday Mini and Apu ate *palak paneer*. Apu wanted to know what it was made from. Amma told them that the **ingredients** of *palak paneer* are: spinach (*palak*), *paneer* (from milk), onion, garlic, ginger, chilli, turmeric (*haldi*), and salt.

List some foods that you and your friends have eaten recently. What ingredients are these foods made from? (WorkBook page 117)

Find out if each ingredient came from a plant or an animal, or from somewhere else. Name the plant or animal (WorkBook page 118).

Classroom experience

The brief story helped introduce the term 'ingredients'. Many students knew the ingredients of cooked rice, tea, *nimbu pani* and potato chips; a few knew of more elaborate foods like curries. Most had helped in the kitchen while some guessed from observation of foods, eg. you see mustard seeds in sabzi; or if it is yellow it must have turmeric, etc. They gave most food names in their mother-tongue while I introduced common English words with spellings (see Glossary of food terms in *Small Science Class 3 Teacher's Book*, pages 232-243).

In Class 3 students had learnt names of fruits, vegetables, cereals and pulses in common use. I asked them to observe find out names of the large variety of foods in the market including meat, fish and shellfish, even those that might be outside their regular diet.

Students' responses

Students knew that chapati is made from wheat flour but not that maida and rava were also kinds of wheat flour, and they had some strange ideas about unfamiliar foods. Some believed that noodles were made from snakes and worms (so did not eat them), or from plant stems. They were better informed about home-made foods: that *udad dal* is used in *dosas* and gram flour is used to make *bhajjias*. They completed the Tables in the Work-Book with help from their parents, some mentioning the parts of the plants too. Some brought empty packets of masala etc. with ingredients listed.

Some foods we ate	**Ingredients**
Rava sago kheer	rava, sago, milk, sugar and cardamom (*elaichi*)

Ingredient	**P or A?**	**Name of plant or animal**
Rava	P	seed of wheat plant
sago	P	root of tapioca plant
milk	A	from cow or buffalo
sugar	P	stem of sugarcane
cardamom	P	fruit of cardamom plant

2. Which parts of plants do we eat? (Home-work + 1 period discussion)

On pages 119 to 120 in your WorkBook are pictures of many food plants. Match the plants with their names in the list.

Label those parts of the plant that you can recognise: root, trunk, stem, branch, leaf, flower, fruit or seed. Circle the names of the parts that you eat.

In which of the plants are two or more parts edible?

Plants illustrated in the WorkBook (names of their commonly eaten parts are given in brackets):

WorkBook page 119

Row 1: mango (flowers, raw and ripe fruit), orange (ripe fruit)

Row 2: onion (root, tender leaves, seeds), rice (seeds), radish (root, leaves)

Row 3: cauliflower (flower), pea (seeds, tender pods), spinach (leaves)

WorkBook page 120

Row 1: Cinnamon (bark), jowar (seeds), sunflower (seeds), wheat (seeds)

Row 2: carrot (root), ginger (underground stem, leaves), arbi (underground stem stem, leaves)

WorkBook page 121

Row 1: sugarcane (stem), bajra (seeds), banana (flower, fruit, inner stem), coconut (tender and ripe fruit)

Row 2: beet (root, leaves), amaranth (leaves), purslane (leaves), tomato (raw and ripe fruit), mustard (seeds, leaves)

Classroom experience

Students had to combine their knowledge of food with what they had learnt about parts of plants. Many learnt for the first time that carrots, onions, potatoes etc. grow under the ground. They found the banana plant to be one where the maximum number of parts are edible.

> Foods from different parts of the plant (names of plants drawn in the Work-Book are printed in bold):
> Root - **carrot**, **beetroot**, sweet potato, **radish (*mooli*)**, **turnip (salgam)**
> Bulb - **onion**, garlic, leek

Tuber (or underground stems - differ from roots because they have 'eyes' with 'buds' from which a new plants can sprout) - **ginger**, **arbi**, potato, yam, tapioca, turmeric, arrowroot
Stem - **sugarcane**, sugar, **banana stem**, green leafy stems, lotus stem
Tender shoots - asparagus, bamboo, rhubarb, artichoke
Bark - **cinnamon**, bay leaf
Leaf - Leafy vegetables like **spinach**, **purslane** and **amaranth**, cabbage, coriander, curry leaves, bay leaves (tej patta), tea
Flower - **caulifower**, broccoli, banana flower, saffron
Fruit - All fruits, **orange**, **banana**, amla, **mango** etc., pumpkin, cucumber, gourds (like *lauki*, *karela*, *padwal*, *petha*), **tomato**, **brinjal**, bhindi, chillies, beans, drumstick, tamarind, some nuts
Seed - All cereals e.g. **rice**, **wheat**, **jowar** and **bajra**; pulses, **peas**, some nuts, oilseeds like til, **sunflower** and **mustard**, **coconut**, coffee

3. Foods that come from animals (2 periods; TB 75, WB p. 122)

a. Read your list of foods from animals. Write the names of these animals on slips of paper. On the other side of the slip write the name of the food we get from that animal, like, milk, eggs or meat.

Sort the slips into groups in different ways. Write the names of the animals in the correct parts of the circles in your WorkBook on page 122.

Students' responses

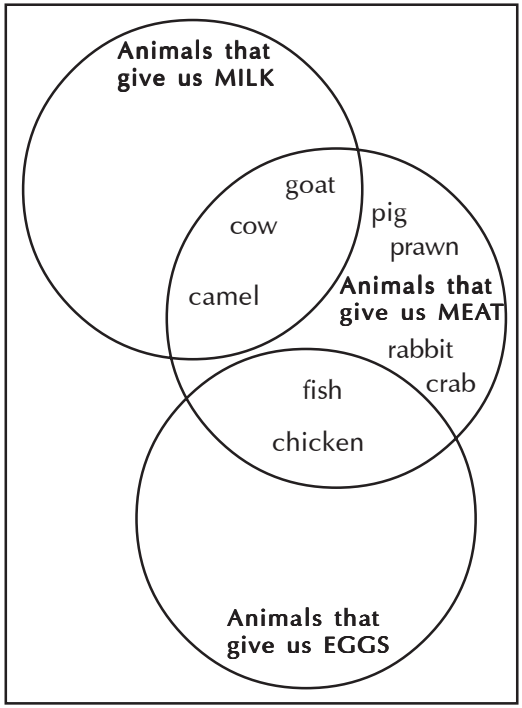
Students gave examples from their experience and also sorted them into domestic and wild animals for *Interesting question* 5.

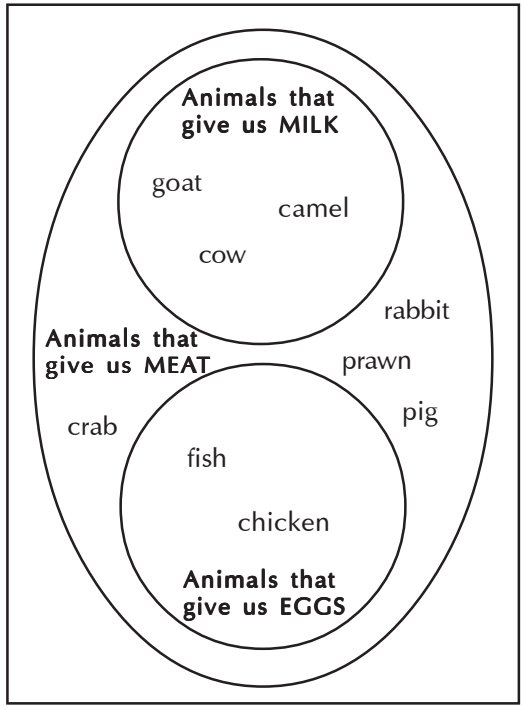
Domestic: goat, sheep, cow, buffalo, pig, chicken, duck, goose, turkey ...

Wild: varieties of fish, shrimp, crab, clam, oyster, several kinds of birds eg. wild fowl, pigeon, partridge (*teetar*), rabbit, hare, boar (wild pig), deer ... Some of these, like shark,

black buck and some types of partridge, are now endangered. Some students knew of an incident in which a film actor had been caught by the Bishnoi people (see page 212) for illegally hunting black buck in Rajasthan.

The exercise on page 122 of the WorkBook recalled the Venn diagram technique which was introduced in Chapter 1 *Figure it out*. This diagram (on left) was unusual since all the animals without exeption lay inside the 'Meat' circle. It could also be drawn (as on right) with 'Milk' and 'Eggs' forming two non-intersecting circles inside the larger one. I asked students which names of animals might lie outside all the circles (animals from which we do not get food).





The other sorting criteria we used, besides domestic or wild animals, were: animals living in water, land or air; birds, mammals, fish and shellfish.

b. People get food from a number of animals. Which foods do these animals eat?

buffalo goat chicken fish

If you do not know what food some animal eats, think of how you can find out.

The general idea to be conveyed is that **all** our foods ultimately come from plants. Even the animals that we eat have grown by eating plants. The feed of domestic animals could be natural or prepared. Eg. a cow, buffalo or horse could graze on grass and leaves, or eat food prepared out of cereal husk and bran, oilseed cakes, shredded crop stems and straw or hay. These ingredients are by-products in the processing of plants for human needs. After rice and wheat are polished/ refined, the bran which is left over is added to cattle feed. The powder produced while breaking whole pulses into dals, and the residue ('oil cake') left after pressing oil from groundnuts, sesame, cotton seed etc. (it contains proteins, vitamins, minerals, fibre and fat), all form nutritious feed for dairy animals.

Nowadays animal by-products like fish, meat, blood and bonemeal are also fed to these normally herbivorous animals. Feeding meat to these animals (eg. cow meat to cows) can lead to spread of diseases from the dead animals to the live ones (eg. the deadly "mad cow disease").

What do animals eat?

Animal	Natural feed	Prepared feed
buffalo	grass, tender leaves (wild or cultivated)	dried grass, stems, grains and seeds, oil-seed cakes (from groundnut, sesame, mustard, soyabean, cotton), *dal churi* (fermented fodder gives better milk yield), fishmeal, bonemeal
goat	Though they enjoy the same food as cows and buffaloes, goats can also make do with less succulent leaves or scrub grass. In India they are often left out to graze.	
chicken	seeds, worms, insects	plant and animal by-products, high-protein grains, seaweed, crushed shells for calcium to build their eggshells, grit or small stones which stay in their gizzard and help grind up their food
fish	microbes in water (plankton), water plants, tiny crusta-ceans, small fish	by products of plants and animals, especially fish and crustaceans

4. How crops are grown (4 periods + field trip + home-work; TB p. 76)

a. Name some food and other crops that are grown in your area. Visit a farm and find out how some of these crops are grown.

Field trip

A field visit would be easy to organise for rural schools - rural students who might already be familiar with agricultural activities would still learn a lot by talking with farmers. For urban students the field trip might pose some difficulty. The best time for the visit being the monsoon, there would be problems of transport and logistics; besides in one visit one could observe at most a small part of any activity. However a trip to a farm at any convenient time, seeing a real field, talking with a farmer, even a visit to a rice mill, would be worthwhile and also helpful in answering some of the questions asked in the TextBook.

b. These pictures show how rice (or 'paddy') is grown. Find out what is happening in each picture (WorkBook pages 123-126).

Rice forms the major staple diet in most parts of India, making up 50% of India's total cereal consumption (wheat constitutes only 16%). Rice was cultivated in the Gangetic plain in the late mesolithic period (9000-8000 B.C.) and in the Harappan civilisation (2300 B.C.). It is grown as a *kharif* or a *rabi* crop, from Rajasthan to Arunachal Pradesh and from Kerala to Jammu and Kashmir. Although a crop of the warm tropical wetlands, it also grows in the cooler temperate regions of China, Japan and Australia. Of all countries in the world India has the largest area of land under rice cultivation, though the production per hectare is low. The Table shows a comparison with China and Japan:

Country	Land under rice cultivation millions of hectare	Total production million metric tons	Production/area kg/hectare
India	40	79	1975
China	37	130	3534
Japan	2.5	16	6250

Classroom experience

Rice growing, its seasonal tasks and festivals associated the sowing (eg. *Akshaya thritiya*), transplanting and harvesting (eg. *Pongal* and *Onam*) seasons, are a part of Indian cultures and are often described in stories and songs. Agricultural tasks are carried out to the tune

and rhythm of certain songs. Students in my class knew a Marathi folk song and dance sequence describing the process of rice growing.

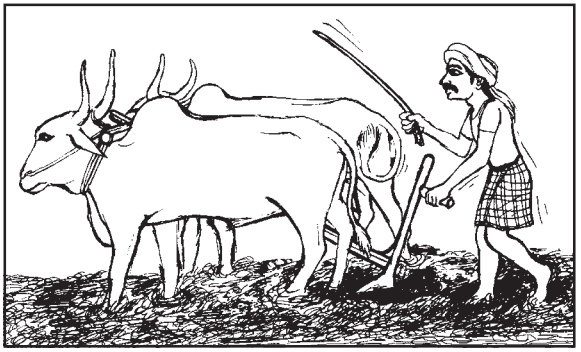
In dry areas rice may be grown without transplanting. Sometimes in this method after the crop is 1-2 months old and the weeding and application of fertiliser is completed, rain water is collected in the fields and it is converted into a wetland crop.

The illustrations on pages 76-78 of the TextBook show the stages in rice cultivation by the 'wet' system (this system needs more water but has many advantages). The crop is initially grown in a small nursery that takes up only one-tenth the area of the larger field. In this small area the seedlings can be better managed: irrigation and plant protection is easier, and only healthy seedlings can be picked out for transplanting.

Other crops are grown similarly except for the flooding and transplanting stages which are unique to rice.

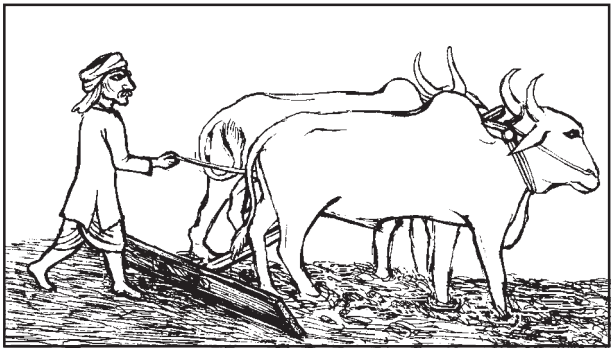
Explanation of TextBook pictures

(1) Ploughing and applying manure

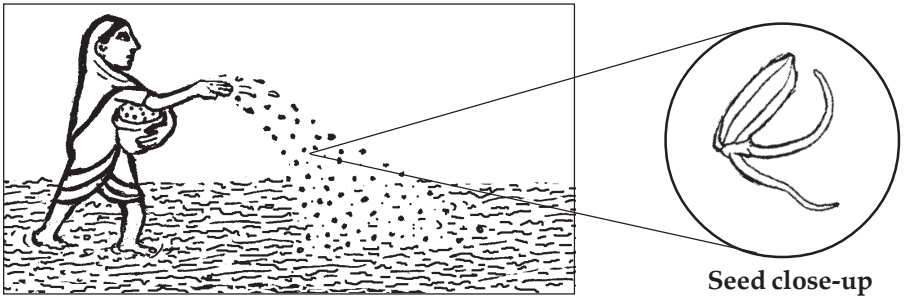


The nursery is first harrowed (see page 268) and ploughed. Pictures (1) and (2) show a plough and soil plank being pulled by a pair of bullocks. In large farms a tractor might be used to pull a much larger plough. (See page 79 of the TextBook for pictures of a harrow and a plough that can be pulled by a tractor and a wooden plough usually pulled by bullocks.). The nursery might be first covered with manure and then flooded. Flooding submerges the old weeds and stubble, which decompose releasing nutrients and also making a soft seed-bed.

(2) Levelling The nursery plot is levelled using a long 'soil plank'.



(3) Sowing by broadcasting sprouting seeds onto wet nursery plot



Seed close-up

Usually before planting, the seeds are soaked in water for a day, drained and kept to sprout in a warm, moist and dark place. The picture shows the partly-sprouted seeds being 'broadcast', that is, thrown so that they spread evenly on the soft soil.

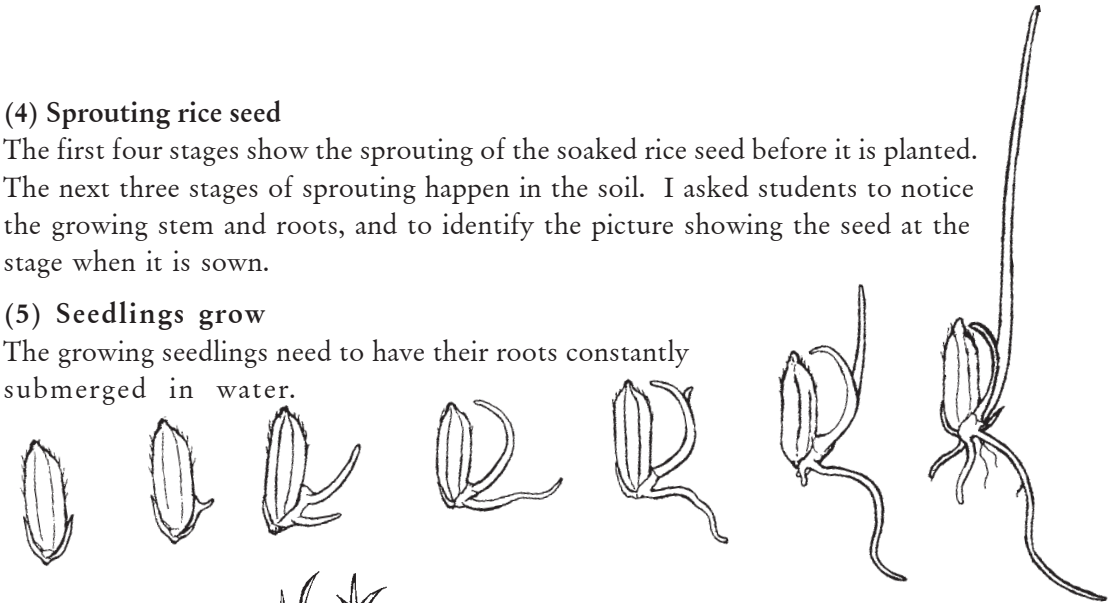
Urban students who have seen only polished rice may not recognise a rice 'seed'. Students in my city class had been through *Small Science Class 3* where in Chapter 3 they had found out that polished rice does not sprout. Most had also seen a whole grain of rice. The next set of pictures show the whole grain i.e., seed, as it goes through the milling and polishing process.

(4) Sprouting rice seed

The first four stages show the sprouting of the soaked rice seed before it is planted. The next three stages of sprouting happen in the soil. I asked students to notice the growing stem and roots, and to identify the picture showing the seed at the stage when it is sown.

(5) Seedlings grow

The growing seedlings need to have their roots constantly submerged in water.



When the seedlings have grown 4-5 leaves they are ready to be transplanted. This stage might take from 14 to 40 days depending on the type of rice, the temperature and availability of water.

In the meanwhile the second field is levelled, ploughed and manure or fertiliser is spread on it. This second field is then flooded. Flooding of the nursery in the first stage, and later of the larger field, is useful in many ways. The weeds are submerged and killed while the rice seedlings get a head start. The ground is softened and the soil nutrients dissolve in water, so are better absorbed by the seedlings.

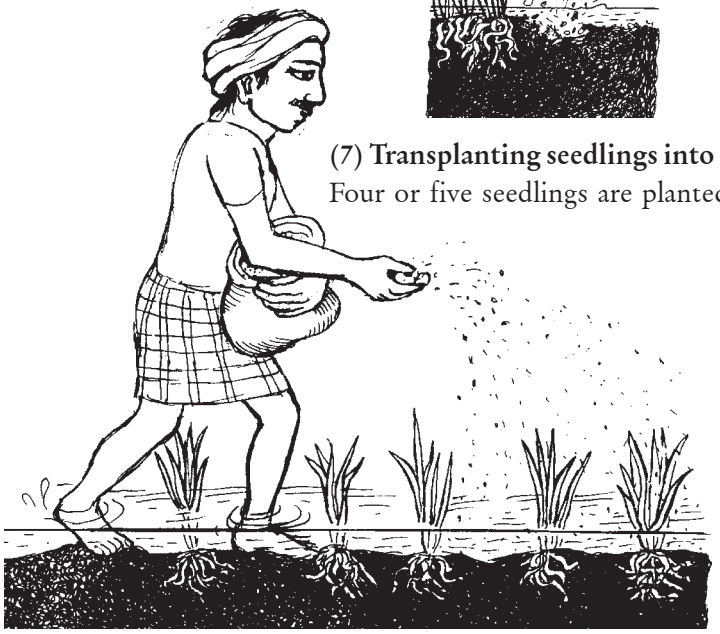
Rice plants survive in the flooded fields because they are native wetland plants. Like sugarcane, lotus and water lily, they have a system of tubes (aerenchyma) which transport air from the leaves to the stem and roots, enabling the roots to breathe even in flooded conditions. (See Chapter 7, pages 202 and 219.)

(6) Removing seedlings from the nursery plot

The seedlings are pulled out along with their roots to be re-planted in the prepared field. This is called transplanting.

(7) Transplanting seedlings into flooded fields

Four or five seedlings are planted in a bunch. The bunches are spaced out in rows.



(8) Applying pesticides

The growing rice crop is attractive food for moth caterpillars, paddy beetles and their larvae, paddy grasshoppers and aphids. Some eat the leaves, others bore through the root and stem, or suck the juice from the tender rice grains. To control these pests, pesticides might be dusted or sprayed on the crop. (For other, safer ways of controlling pests see *Ask and find out*, pages 286-288.)

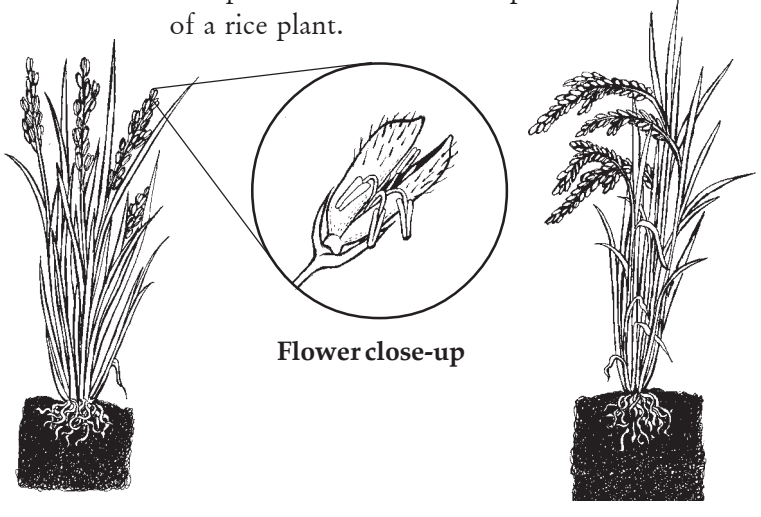
(9) Weeding

Weeds grow fast and unless they are removed, they will compete with the rice for space and nutrients, not allowing the crop to grow. Sometimes herbicides are added to kill the weeds, but they are poisonous.

Fertilisers, pesticides and herbicides are ultimately washed away with the water. Either through water, food or air they get into the bodies of animals and are passed along the food chain, causing much harm (see pages 278-279 and 286-288 for dangers of pesticides and alternatives to them).

(10) Flowering

The picture shows a close-up of the flower of a rice plant.



Flower close-up

(11) Drying out in drained field

About a month after the crop has flowered, the grains - the fruits of the plant - ripen. (The total time between sowing and harvesting is 100 - 200 days.) During ripening the field is drained of water. The paddy (rough rice) is harvested while it is still a little wet. If it were allowed to ripen completely on the plant the grains would fall off on their own leading to wastage.

(12) Harvesting

Harvesting could be done by hand using a sickle or mechanically with a tractor and harvester. After harvesting the grain is set out to dry in the field. If the paddy is not dried well fungus will grow on it.

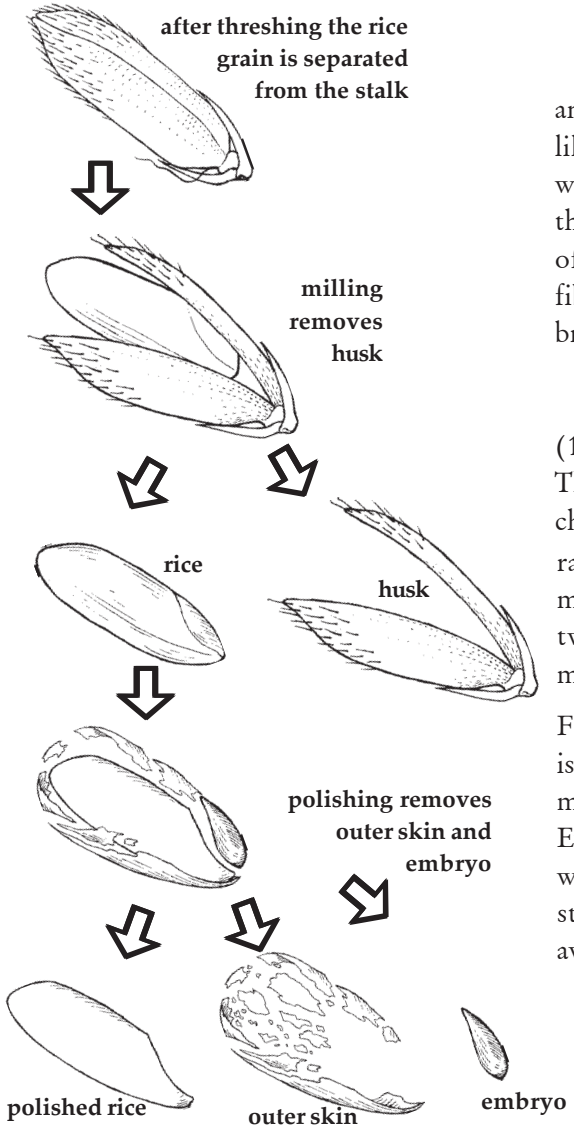
(13) Threshing

The dry plant stalks are beaten on a hard surface to remove the grain. Threshing is also helped by having bullocks trample the grain; large farms use threshing machines. Some farmers use elephants, others might keep the stalks on the highway for trucks to go over them helping to remove the grain!

After threshing the grains are winnowed. In winnowing the grains are poured out of a basket or tray held high up. The wind (natural or produced by a fan) blows the chaff, dust and lighter seeds aside while the heavy grains collect below.

The sequence of pictures on the next page shows the stages of milling and polishing of a rice grain. In milling the coarse husk is split and then removed. Hand-milling is done by pounding the paddy or rubbing it between rough wooden boards.

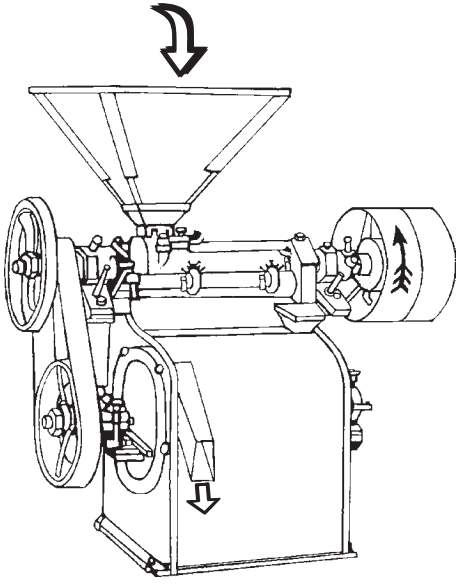
What happens during milling and polishing:



The milled rice has a light brown colour. It is edible, tasty and also very nutritious. But this brown rice easily attracts pests like insects and fungus. To make the rice last long and look white, it is polished. In polishing, the outer skin ('bran') and the living embryo ('germ') are removed. With these are lost some of the protein and fat, and most of the vitamins, minerals and fibre. (See Small Science Class 3 Teacher's Book, page 115.) The bran is used in animal feed (see pages 257-258).

(14) Milling and polishing machine

The picture shows a modern compact milling and polishing machine. Often however the milling and polishing are done separately in large-scale machines housed in two or three storey mills.



Finally the rice grain is transported to the market to be sold. Everywhere along its way the rice has to be stored in a dry place away from pests.

Some problems caused by farming

As the human population increases there is pressure to bring more and more land under cultivation, and to increase the yield from existing farms. Forests are cut down and crops are planted in their place, leading to soil erosion. Since the Green Revolution, improved high-yielding varieties of seeds have come into use, which require use of chemical fertilisers, pesticides and herbicides. Today in most parts of the world these chemicals are considered indispensable. However they lead to serious deterioration of the environment.

The bulk of these chemicals are washed into lakes, rivers and bays, thus polluting our water sources and poisoning plants and animals. (For pesticides in the food chain see pages 278-279). Some of the high-yielding crops need heavy irrigation. This excess water dissolves salts in the lower soil and brings them to the surface, making the top soil salty: for several years then this soil is not useful for growing crops. (One remedy is to plant trees with deep roots which can absorb the excess water.)

Insecticides destroy pests but they also destroy useful insects like bees (which help pollinate flowers), and wasps, ladybugs, crickets, dragon flies, damsel flies, water striders, spiders and centipedes (which eat the pests). If these natural predators are destroyed the system becomes permanently dependent on insecticides. Repeated use of pesticides has led to the emergence of chemical-resistant "super pests". (For methods to reduce reliance on fertilizers and pesticides see pages 286-288.)

Tools and machinery used in farming (TB p. 78, WB p. 124)

Find out how some of these tools are used. What farming or gardening tools are used in your area?

Tools illustrated on page 78 (bottom)

Name of the Tool		Use
English	**Hindi/Marathi**	
Sickle	*Koyta/Vila*	Harvesting,, cutting grass and other plants
Shovel (hoe)	*Phavda*	Digging; moving loose soil
Pick or pick-axe	*Kudal*	Digging hard soil, making roads

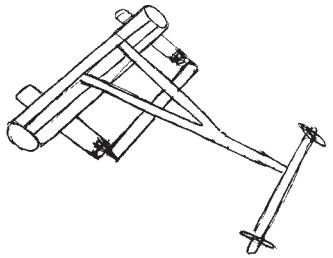
Classroom experience

Even urban students had seen these or similar tools at home, in the garden, in construction, road-making, etc. They had seen sickles used by coconut and other fruit vendors. In Activity 5 they got a chance to use some of the tools.

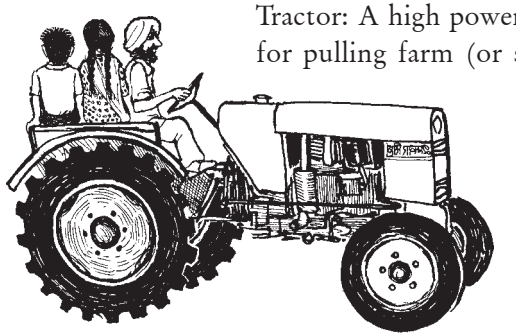
Tools and machinery illustrated on page 79

Harrow: Before cultivating any piece of land, old weeds are removed and the soil is loosened with a harrow. This is a kind of harrow that is pulled by a tractor.

Here is a picture of a harrow that can be pulled by bullocks.

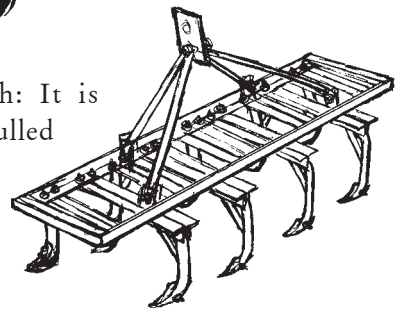


Tractor: A high power, slow speed vehicle used for pulling farm (or sometimes building) machinery. The wheels are shaped so that they can move over even soft soil.



Wooden plough: Can be pulled by bullocks or by hand.

Tractor plough: It is heavy and is pulled by a tractor.



Is rice grown in your area? If not, in which nearby places is rice is grown?

Find out how rice is grown in your area or in the closest place. Find answers to the following questions.

When are the seeds sown?

When are rice seedlings transplanted? What do farmers do before they transplant the seedlings? When is paddy harvested?

How long does it take from the time the seeds are planted until the crop is harvested?

What happens after the paddy is harvested?

Who does most of the work in growing and harvesting rice, men or women?

Which part of growing rice do you think is the hardest? Why?

Find out more and use these pictures to help you write a story about how rice is grown.

Are other crops in your area grown in the same way? What are the differences?

The answers to these questions have to be found by students through the field trip, by reading and observing the pictures.

Think! Think!

Why do we need to plough the field before sowing seeds?

Every year when it rains the soil is pressed together. Rain followed by hot sunshine makes the soil hard. If the soil remains like this the next rain cannot sink into it easily. Ploughing is a way of digging up a large stretch of land.

It allows the water to sink into the soil and loosens the soil so that the roots of plants go down easily. (Remarkably, a large number of earthworms and other soil organisms together can do the same job as a plough!) Ploughing lets air into the soil - air which is needed for the roots to breathe and also for microbes in the soil to breathe and multiply. Many kinds of soil microbes help dead plants and animals decompose, making manure which in turn helps the plant grow. Ploughed soil also covers the seeds letting them remain in warm, moist and dark surroundings where they sprout better.

5. Grow your own food (2 periods discussion + 2 periods outdoors + group assignments; TB p. 80)

a. Plan how you would grow a crop (WorkBook pages 126-127):

What crop to sow

In which soil

How to plough your 'field'

How much space between the plants

How often to water

What care to take to prevent any damage

How make the crop grow better or faster

When to harvest the crop

Whether you need to separate the food from other parts of the plant

Whether you have to dry it, peel or shell it, wash it or cook it

Which parts of the plant to throw away

What will happen to these parts

Classroom experience

Planning how to grow a crop is a useful classroom exercise. Especially for urban students it would help to visualise the process even though in some cases it might not be possible to carry it out in the school.

b. Follow your plan and grow some food on a small patch of land or inside a tray.

OR

Plant the seeds of a ripe tomato, cucumber, chilli or any other food plant.

Take care of the plants till they bear fruit.

Classroom experience

We chose the first option, of growing a 'field' of plants on a patch of land. These were urban students of whom only a few had some experience of village life. While they had a rough idea of ploughing, sowing and irrigating, they were less sure about weeding, harvesting, threshing etc. I explained these with the help of the illustrations. I reminded them that only whole grains sprout and not, say split dal and milled rice. We chose moong, mustard and jowar.

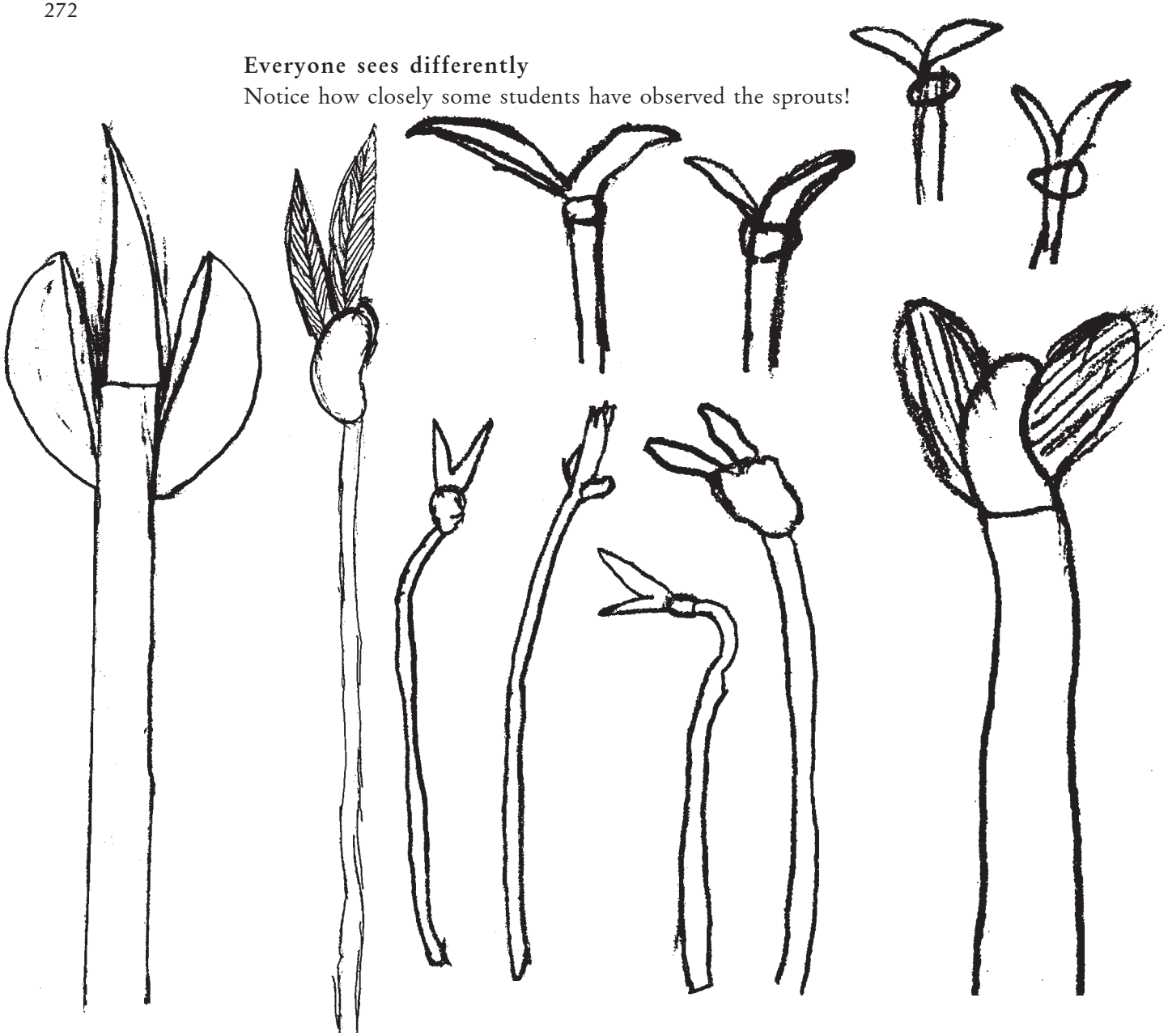
Outdoor work

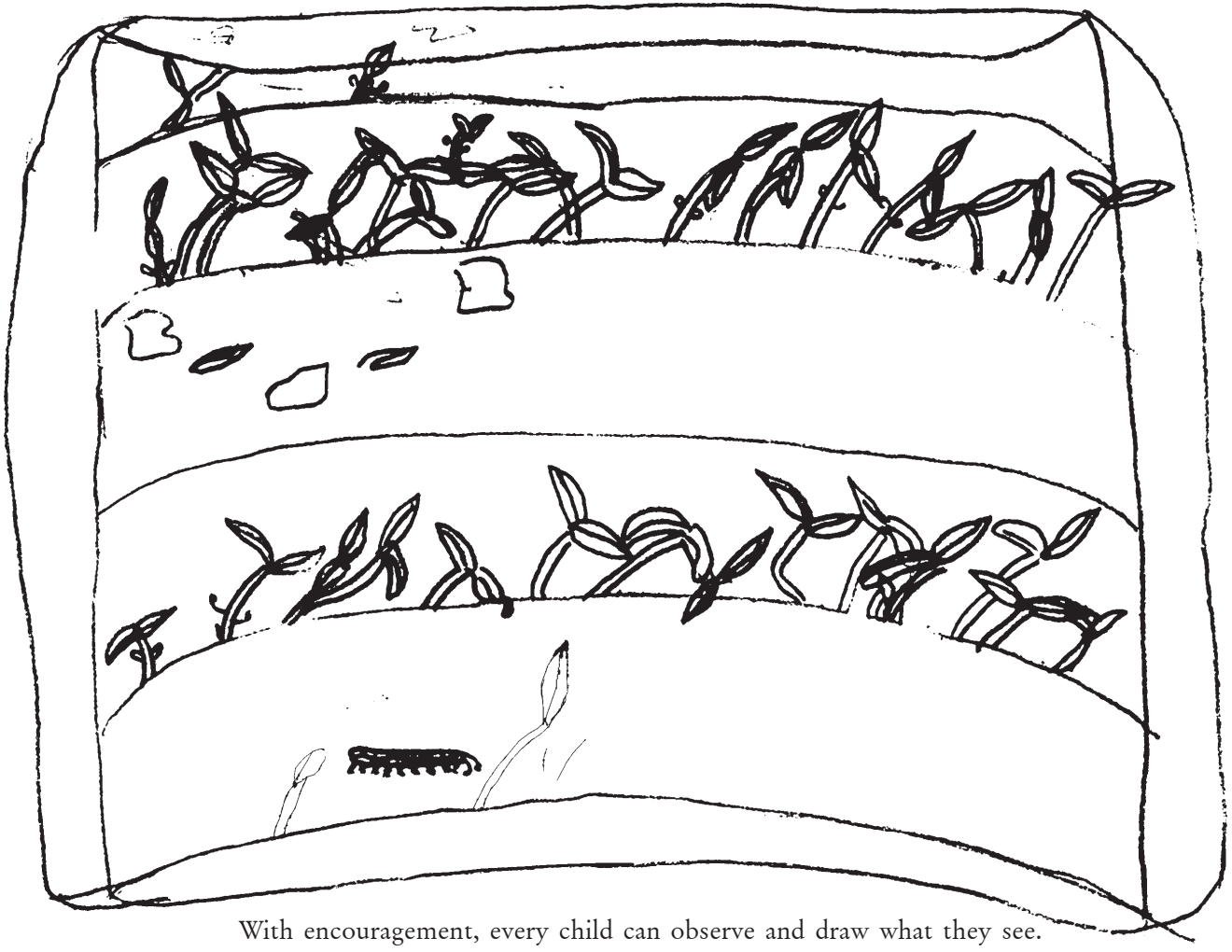
The ground was hard and had to be loosened with a pick-axe (pick). I was surprised that many of the students, even some weak-looking girls, were quite good at digging with a pick-axe. They made furrows in the ground using a sickle; some were expert at inserting the sickle in the ground to lift the soil (not all students would know the technique of using these tools but they could learn by watching experienced students or older persons).

Students were thrilled at the sight of the first seedlings. They observed the field regularly before coming in the class or during break time. Every few days they made drawings of the plants and of the field, which improved their observations considerably. During these outdoor sessions students also looked for damage caused by pests in their own and the surrounding plants (for Activity 7).

Everyone sees differently

Notice how closely some students have observed the sprouts!





With encouragement, every child can observe and draw what they see.
The students who drew these pictures were happily surprised to see what they could do (at first some of them thought they could not draw)!
I just kept reminding them to keep looking as they were drawing.

6. Make your own flour (Double period; TB p. 80)

Take a cereal like, rice, wheat or corn, or a pulse like chana or urad. Measure out a little of this grain. Grind the grain between two clean stones to get flour. What shape of stones will you use? (WorkBook pages 127-128)

Will the flour fill the same number of measures as the grain, or more or less? Why? Measure it and see.

Mix the flour with water and shape it into a ball. Flatten the ball to make a roti. Is your roti clean? Would you eat it?

Are some grains easy to shape? Which ones? Is it easier to make a roti out of coarse flour or fine flour?

Classroom experience

I helped students to identify all the cereals and pulses they had brought. Before doing the activity I asked if they had seen flour being made. Most had been to a flour mill or *chakki* and realised it worked on electricity. They had seen a grinding stone; though they did not know the term *sil-batta* in Hindi, one student knew the Tamil name. In a History lesson in Class 3 students had learnt about people of the Stone Age: the grinding stone used in India has not changed much since the later stone age. For the activity they suggested that a large flat stone (or a tiled floor) and a rounded stone would work well together. Those who did not find rounded stones worked with other shapes. The stones were washed and dried before use.

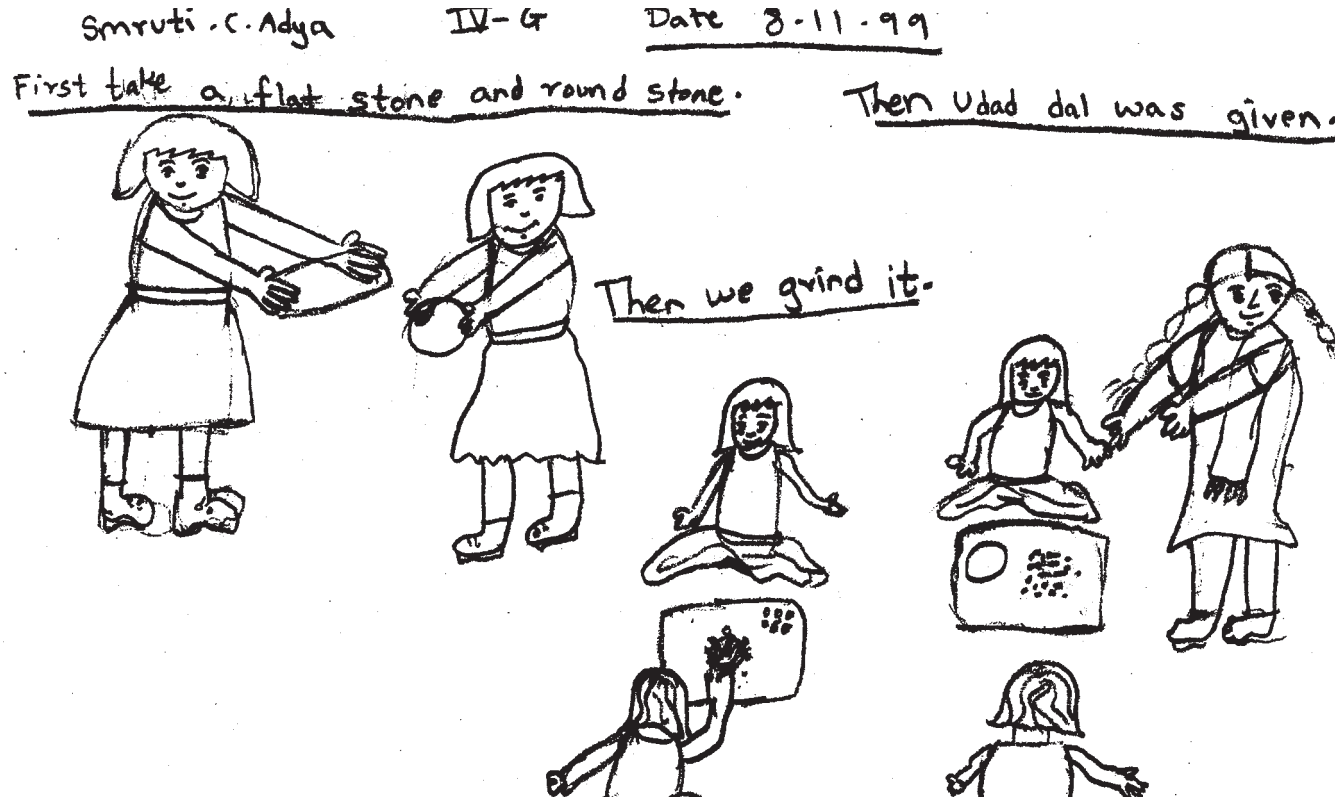
Students' observations

Students wrote in the WorkBook their guess for the number of cap-fulls of flour. Some guessed that it would be equal to the number of capfulls of grain, some that it would be less (because the flour would settle down, was one reason given) or that it would be more (the food is packed tight in the grain, it becomes loose outside). The latter reasoning is correct: flour occupies a larger volume than the grain before grinding. Students who had taken grain to the mill knew this from experience. In doing this activity however quite a

bit of flour was lost at each step, so the volume of flour turned out to be less than the volume of grain.

Many of the rotis were quite dirty-looking: students realised that processing of food needs to be done in clean conditions. Wheat was the easiest to shape followed by other cereals. The pulse flours did not shape so easily. Fine flour could be shaped more easily than coarse flour. Wheat (which contains more of the sticky protein gluten) was the easiest to shape.

The students made wonderful, large drawings of how they made the flour.



7. Pests and pesticides (Double period; TB p. 81, WB p. 128)

Many kinds of insects eat the roots, stems, leaves, flowers and fruits of plants.

Some burrow inside these plant parts.

Fungus, a kind of small living thing, grows on plants and damages them.

a. Was your crop eaten or damaged while it was growing?

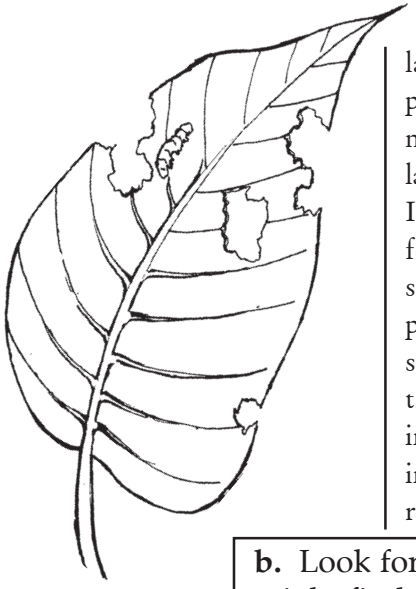
Look for food crops or other plants that have been damaged. The leaves, bark, flowers or fruit might have been eaten, the leaves might be curled or have swellings or markings. Try to find out how this damage was caused (WorkBook page 128).

Students' observations

Some students, with experience of farming or gardening, were familiar with crop and garden pests. In Activity 5 we had observed our moong seeds being eaten by birds (though on a larger scale, crop damage caused by birds is tolerable considering their usefulness in eating harmful insects). During outdoor sessions students had observed plants infested by insects and fungus.

Small holes and tears in leaves are evidence of damage caused by insects, often caterpillars. A wart or swelling may hold an insect inside it; a crumpled or twisted leaf might show that aphids have been sucking its juice. Fungal infection is usually seen as white, black, yellow or brown spots or a fluffy or powdery coating on leaves. Some discolorations might also be caused by bacterial or viral infections. Root infestations like boring (tunneling) worms, insects or fungus are not seen above the ground but they lead to wilting of plants.

Every plant has characteristic insects and other living things dependent on it. Some of these associations might be useful or harmless for the plants (for example bees help in pollination, wasps and ladybugs eat more harmful insects). In small numbers even the pests may not cause much harm: in the wild they might actually serve to keep in check the plant population. But



large numbers of these pests together cause immense harm. In farms and plantations large numbers of the same kind of plant are grown in one place, making it easy for pests to spread from one plant to another, multiply into large numbers, and thus destroy the crop.

Insects are the most common agricultural pests. They multiply rapidly when food is plentiful, at other times they stay dormant or their numbers remain small. For example the desert locust occurs in India in regular cycles (see pages 211-212). The Deccan wingless grasshopper is seen only in the Kharif season. Many pests are abundant in the monsoons; at the end of the season they lay their eggs in the soil, to hatch only in the next monsoon. Some insects like aphids and the whitefly, besides sucking plant sap, also carry viral infestations. Other crop pests might be mammals like rats, bats, monkeys, rabbits, squirrels etc., roundworms, mites, crabs, millipedes, snails and slugs.

b. Look for caterpillars and other insects in vegetables and fruits. You might find insects inside peas, beans, cauliflower, cabbage, spinach, mango, apple, etc.

Students' observations

In Chapter 6 we had recalled the pea caterpillar. Students also remembered caterpillars in cauliflower, brinjal and other vegetables and white cottony fungus seen on rotting beans. Due to widespread use of pesticides the incidence of pests is lower than it was some years ago.

c. Look for insects living in grain, spices or other foods stored in the kitchen.

Students' observations

After the discussions of Chapter 6 students had been looking for samples of grains infested by insects. They brought these to class. We observed the larva, pupa and adult stages of the insects in rice.

d. Pesticides are poisons that are put on crops to kill harmful insects and other small living things. Find out the names of some pesticides used on crops or garden plants.

Do you use any pesticides in your house? Do you put any pesticides in food grains?

Could pesticides be harmful to us? Why do you think so?

Take care!

Pesticides are poisonous. They can make you sick.

Wash all grains, vegetables, fruit and meat well to remove pesticides and other dirt and germs.

A wide variety of agricultural and garden pesticides are available. A few derived from plants like, neem, tobacco and chrysanthamums are less dangerous to other living things. Others are inorganic pesticides like compounds of arsenic, zinc, sulphur, phosphorus and fluorine. A wide variety of organic synthetic pesticides are commonly used. Example names are, DDT (Dichloro diphenyl trichloro ethane), BHC (Benzene hexachloride), Chlordane, Endrin, Aldrin, Endosulfan and Diazinon. Pesticides are usually dusted or sprayed on crops while some types are put in the soil.

Some pesticides act on particular species of pests but most are also harmful to other harmless or useful animals. In 1960 Rachel Carson wrote a book called 'Silent Spring' in which she pointed out the dangers of pesticides. Pesticides get into the bodies of microscopic plants and animals in the soil and water. When these plants and animals are eaten, by say fish, the pesticides get into their bodies. Even if the fish are not seriously poisoned, with each successive meal pesticides build up inside their bodies. A bird that now eats these fish

might get a concentrated, lethal dose. DDT also accumulates in eggshells weakening them and making the shells break before hatching. There are just two out of the numerous ways that pesticides are eaten, passed down the food chain, and accumulate in the bodies of higher animals including human beings, causing sickness and sometimes death.

Know these words

ploughing	transplanting	threshing	fertiliser
flooding	weeding	milling	pesticide
broadcasting	harvesting	polishing	

EXERCISES (12 periods + home-work; WB p. 129)

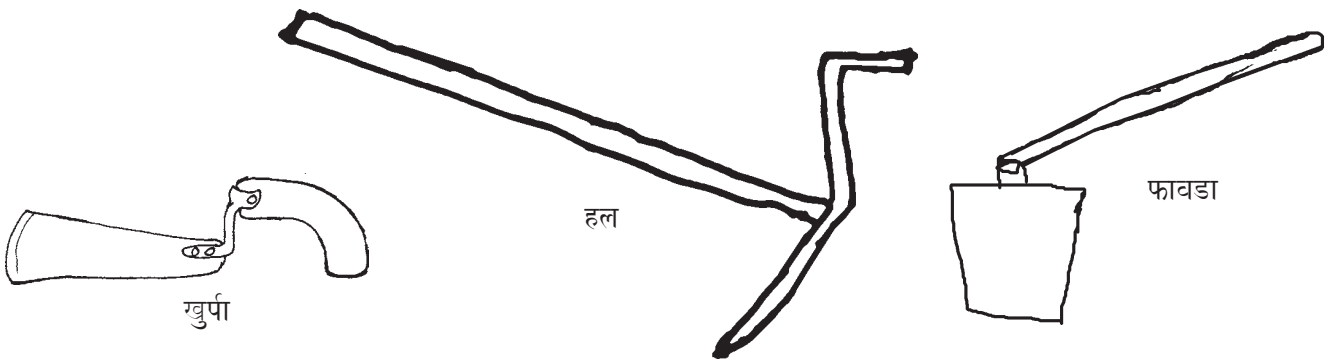
Observation-based exercises

Name and draw

1. Every week after sowing the seeds draw a picture of your field or plants.

See pages 272-273.

2. Draw any farming or gardening tool used in your area.



Interesting questions (WB p. 131)

1. Name one ingredient of food that comes from neither plants nor animals.

The simplest answer is, salt. There might also be some possibly synthetic ingredients like cooking soda, vinegar and citric acid, colours, stabilisers and other additives and preservatives used in commercially packaged food.

2. Put in the right order:

   threshing ploughing harvesting sowing milling irrigating

ploughing, (irrigating), sowing, irrigating, harvesting, threshing, milling

3. Put in the right order:

   bhindi flower cooked *bhindi* unripe *bhindi* on the plant

   chopped *bhindi* ripe *bhindi* sprouting *bhindi* plant

young *bhindi* plant, *bhindi* flower, unripe *bhindi* on the plant, ripe *bhindi*, chopped *bhindi*, cooked *bhindi*.

4. Write the name of the plant, and the part of the plant, from which we get these foods:

   corn coconut oil sugar peas carrot cauliflower

(Done with Activity 2. See page s 254-255)

5. Name some domestic and some wild animals that people eat.

(Done with Activity 3a. See pages 255-256)

6. Name some water plants and animals that people eat.

singhara, lotus, some seaweeds; crab, shrimp, oyster, clam; river fish like rohu (kind of carp), masheer, hilsa; sea fish like pomfret, surmai, eel, shark ...

7. Name some foods eaten on certain festival days.

Seasonal foods are traditionally used at the appropriate times of the year, as some examples from Hindu festivals in Maharashtra and Karnataka show (thanks to Sharada and Jyotsna Vijapurkar for the information):

Gudhi Padva - a dish made of new ripe tamarind, raw green mangoes and neem flowers

Vat Savitri - Ripe mangoes are distributed

Varalakshmi - *Keora* and *parijat* flowers are used in *Puja* (Andhra, Karnataka and Tamilnadu)

Gokulashtami - *Jamun*

Ganesh Chaturthi - New fresh corn; custard apple (*sitaphal)* and *kavat are* still mostly raw, new green tamarind of which a chutney is made in Andhra on this day.

Mahalakshmi - *padval*

Dassera - Marigolds for decoration, a variety of banana (*chitiwale mouz*), ripe custard apple

Sankranthi - *Tilgul* made from sesame seeds and new jaggery; sugarcane, *bor*, new rice, fresh haldi, fresh green chana, *desi gaajar*, red pumpkin, *ghevda* and mixed vegetables. In South India *Pongal* is made with newly harvested rice.

Holi - New wheat ears are roasted in North India.

Classroom discussion (WB p. 132)

Observation and language-based exercises

1. Does everyone around you get enough food to eat? Why do some people not get enough food? What could they do about it?
2. Do you think sometimes people eat too much food, or the wrong kinds of food? Give examples, and tell why you think this happens.

These two questions could raise many issues, depending on students' experiences. Students might be aware that all of us do not get sufficient food, that there could be severe hunger and malnourishment in the midst of plenty of food. Though there is enough food to feed everyone, more than 800 million people in the world are undernourished. In India too we grow enough to feed every person, yet every day more than 20% Indians, including children, go to bed hungry. The problem is most severe in summer when the water sources start drying up. Causes of hunger are not just an economic but ecological, social, and often political. By changing our own attitudes and priorities and better managing our soil and water resources we would begin to tackle this problem.

Some leading questions for the classroom - is the diet of poor people different from that of well-to-do or rich people; in what ways; do you buy grain from ration shops; where does this grain come from; price and quality of grain in ration shops compared to that available in the open market; amount and quality of vegetables and fruits consumed by different people: students might suggest it depends on spending power, priorities, traditional or modern lifestyles or awareness of nutritional value; could people spend more wisely on food and how; think of possible meals in poor and rich households and consider their cost as well as nutritional values: a. broth made of polished rice, b. dal, roti, vegetable and salad, c. whole-grained rice and fish, d. pulao, pakodas and rabri, e. pizza and hamburgers, etc.; what foods are unsuitable as part of daily diet and why; what could be the result of eating too much food, food that is too rich yet lacking in nutrients; what could we do to help people who are starving; could we distribute the food so everyone gets some; could we avoid wastage; how could we conserve our land and water resources to grow food for everyone?

3. What are the advantages and disadvantages of using tractors or animals for ploughing?

For small farms, animals are more cost effective. They are less expensive, cost less to feed compared with fuel cost for tractors and they also give other useful products like manure, milk, meat and leather. Tractors are useful for large farms where they save time and effort.

What's the same? What's different? (WB p. 133)

1. What is the difference between a fruit and a vegetable? Can a fruit be a vegetable? Give some examples.

A 'fruit' refers to part of a plant (it is a technical term) while a 'vegetable' is one constituent of a meal (it is an everyday term). A 'vegetable' might be a fruit, like tomato, or it could be any other part of a plant (see pages 254-255).

2. Give two similarities and two differences between:

a. Raw papaya and ripe papaya (or any other fruit)

b. Raw papaya and cooked papaya (or any other vegetable)

A papaya is used in both a. and b. to illustrate that a fruit can be a vegetable and that 'raw' in everyday language is used to mean either 'unripe' or 'uncooked'. If students are not familiar with a papaya other examples might be substituted. There is some similarity in the processes of ripening and cooking. Unripe or uncooked food might be hard to chew, might stick between the teeth, taste bitter or sometimes give us a stomach ache.

3. People eat only some kinds of plants and animals. Make a list of 5 plants and 5 animals that you think no one eats. For each one, tell why you think people do not eat it.

The differences could be due to safety (is it poisonous), ease of digesting (we cannot digest cellulose as in grass), taste, texture or even social convention (one group of people might eat it while another forbids eating it).

Language-based exercises

Talk and write (WB p. 134)

1. Find out about festivals, songs, and dances celebrating sowing, harvesting or other farming activities.

2. Something I ate today - Imagine and tell a story about where some food came from.
3. Ask your friend to think of some food. Ask questions to help you guess the name of that food. Your friend can only answer "yes" or "no". How many questions did you have to ask before you could guess the answer?

Example: Is it a cooked food? (No) (Guess - it must be something eaten raw) Does it come from a plant? (Yes) Is it either a fruit or part of a fruit? (No) Is it a leaf? (Yes) (Guess - it is a leaf that is eaten raw) Lettuce? (Yes).

Play with words

Play with words

1. Play this game with your friends. The first player says the first letter of any food word. The second player says the next letter so that the word can still be completed into a food word. (It does not matter if this word is different from what the first player had in mind.) A player who cannot think of the next letter gets out. One who completes a food word gets a point.

1st player	C (ucumber)	
2nd player	CH (ocolate)	
3rd player	CHI (ps)	
1st player	CHIC (ken)	
2nd player	CHICK (en)	
3rd player	CHICKP (ea)	etc.

Another way of scoring could be that the one who completes the word **looses** a point in which case each player would try to think of words that would not end on themselves, or in case there is a longer word (like watermelon) of which the shorter one (water) is a part, then on completing the shorter word would add, "continue".

Ask and find out (WB p. 135)

1. What is a weed? What is meant by weeding?
2. What is manure? How it is made and used? What is a chemical fertiliser? Find out the names of some fertilisers.

Manure is the waste matter from animals and plants which is used to provide nutrients for the growth of plants. The texture of manure keeps soil loose, helping to absorb and hold water. Organic matter encourages growth of useful microbes and also reduces the number of harmful nematodes (microscopic eelworms which burrow into plant roots).

What nutrients do plants need? Besides carbon, hydrogen and oxygen (which plants get from air and water) the main elements needed for plant growth are nitrogen (N), phosphorous (P) and potassium (K). These three elements together are referred to as NPK. Besides these are some essential elements needed in smaller amounts - magnesium, calcium and sulphur, and many others required in trace quantity - iron, manganese, boron, zinc, copper, molybdenum, chlorine, nickel, sodium, cobalt and silicon.

The bodies of plants and animals contain all these elements. When soil organisms like earthworms, beetles and finally microbes break down dead plants, animals and their wastes (see Chapter 10), the elements are returned to the soil. "Nitrogen-fixing bacteria" in the soil and some which grow on roots of leguminous plants (eg. peas and beans) take nitrogen from the air and convert it into nitrogen compounds. Leguminous plants are therefore a valuable source of manure. (For composting manure see pages 339-340)

Chemical fertilisers:

These are compounds containing one or more plant nutrients. For example a fertiliser may have a mixture of either ammonium nitrate or urea for N, superphosphate for P and potassium sulphate for K. Lime might be added to

provide calcium and magnesium. Fertilisers are manufactured as powder, granules, pellets or liquids.

3. Can fertilisers and pesticides be harmful to us? In what ways? When fertilisers and pesticides are washed off by rain where will they go?

Fertilisers need to be applied in the correct amounts: in excess they are harmful to plants. Many chemical fertilisers contain acids which kill microbes, earthworms and other beneficial organisms in the soil. Nitrogen-fixing bacteria too are destroyed by repeated use of chemical fertilisers. Fertilisers bind to trace elements in the soil; depletion of trace elements causes fungal and bacterial diseases in plants. Also, fertilisers need to be used with a lot of water, leading to problems of soil erosion, salinity etc. (see page 267).

Nitrates being very soluble in water, get washed out of the soil and accumulate in streams and underground water supplies. Being colourless and odourless they are not detected easily and they are not removed by filteration or boiling. Excessive nitrates in drinking water are suspected to cause cancer of the stomach. In babies below six months of age they reduce the capacity of the blood to carry oxygen, leading to suffocation. Too much N and P in water leads to excessive growth of algae which deplete the oxygen supply needed by other water life.

The dangers of pesticides are described on pages 278-279.

4. Are there pesticides that are not harmful to us? Find out about safe ways of protecting grains from pests, like using neem leaves.

Natural pesticides made out of neem, garlic, persian lilac, *pongam*, etc. are not harmful to us. Some non-toxic ways of protecting stored grains are, mixing them with dried neem leaves or coating with castor oil which can be washed off.

Sometimes after one crop is harvested farmers carry out controlled burning of the stalks left in the field. Unfortunately by this practice the nutrients which would otherwise have enriched the soil are lost, but the advantage is that insect eggs and pupae in the soil are destroyed, thus controlling the pests which would have affected the next crop.

To reduce reliance on pesticides, scientists are trying to develop methods such as biocontrol (using other species to control pests) and genetic engineering to create pest-resistant crops. Scientists are also looking for various ways to stop the pests from reproducing. The good or harmful effects of these methods need to be tested thoroughly. For example, 'predator insects' might eat the crop and other useful insects as well as the pests! New resistant genes might get transmitted to other species in unforseen ways.

Organic farming:

In the meanwhile some farmers are trying to go back to natural methods. Organic farming makes use of the cooperative behaviour of plants, soil and other life forms while avoiding toxic chemical fertilisers and pesticides. Organic farmers use insect repelling plants like garlic, onions, neem and marigold; they rely on soil microbes, predator insects, birds etc. to keep pests in check. During times when the land is not being used for the main crop, grasses and legumes like clover are grown which are useful for grazing animals. The animals provide manure, and when these plants are later ploughed back into the soil they enrich it. Crop-rotation is used in which a pulse crop like tur or soyabean is planted in the moisture remaining after the rice crop is harvested: pulses are legumes which enrich the soil with nitrogen. A well-planned combination and rotation of crops can help control weeds naturally. Plants grown by organic methods are often healthier and better able to resist disease and insect predation.

Some organic farmers go so far as to not even plough the land! They find that in this way the population of earthworms and other soil organisms grows, keeping the soil naturally loosened and enriched. (See the book "The One-Straw Revolution", by Manasobu Fukuoka.)

Quantitative thinking

Figure it out (WB p. 135)

The problems are new and somewhat difficult for students of Class 4. Only one student in my class was able to do them without my help. But the others succeeded to various extents. I think all of them learnt something from finding the required information and getting even a partial solution to the problems.

1. Suppose a family of four cooks 250 grams of rice every day. How much rice will they use in 30 days? (Remember, 1000 grams make 1 kilogram.) Where does your family get rice? How much rice does your household use in one month?

Classroom experience

In 1 day the family uses 250 grams of rice

In 30 days they will use $250 \times 30 = 7500$ grams $= 7\ ½$ kilograms of rice

Students' estimates of the amount of rice used in their household every month ranged from 1 kg to 10 kg.

2. A square metre is a piece of land 1 metre long and 1 metre wide. If you can grow 5 kg of rice on each square metre of land, how many square metres will it take to feed your family for one year?

Suppose, as in the above calculation, our family uses 7.5 kg of rice in one month.

In 12 months we will use $12 \times 7.5 = 90$ kg of rice

If 5 kg of rice grows on 1 square metre of land,

90 kg of rice will grow on $90/5 = 18$ square metres of land.

(Note that this estimate of yield is an optimistic one, and the question considers only the rice part of the diet. In practice the amount of land needed to support one family would be several times more.)

Some common measures of area:
Acre: Originated in England as an approximate unit denoting the amount of land ploughed by a pair of oxen in a day; later standardised to 160 rods, where 1 rod = 16.5 ft So,
1 acre = 43,560 sq ft = 4,047 sq m
Are and Hectare: Metric units of area,
1 are = 100 sq m
1 hectare = 10,000 sq m
Some common Indian measures of area are, bigha, guntha and cent. They vary over different regions but some notional magnitudes are,
1 bigha = 5/8 acre
1 guntha = 1/40 acre = 121 sq yards
1 cent = 1/100 acre

Show and tell

1. Bring some food that you might carry on a long journey. Now tell the names of some foods that you would **not** carry on a long journey. Tell the class why.

See Chapter 10 *Interesting questions* 2 and 6 (pages 337 and 338).

Ask a question (WB p. 136)

1. Ask questions about where our foods come from. Think of how you will try to find the answers.

Students' question: What is 'boiled rice'?

This is also known as parboiled rice and is common in South India. As much as half the rice grown in India is parboiled. The paddy is soaked in cold water, then boiled or steamed, and finally sometimes roasted in hot sand. After it is dry the husk is detached more easily. The parboiling treatment helps to ab-

sorb some of the vitamins and minerals from the bran into the grain so that fewer nutrients are lost later in the polishing process.

DID YOU KNOW?

To grow one kilogram of grain we need a few thousand litres of water.

Most of this water is let out into the air by the leaves.

See pages 197 and 227.

CHAPTER 9

Food in our bodies

STORY (1 period; TB p. 85)

Eat your lunch

"Amma, I don't like doodhi!" Apu complained, "I don't want lunch today."

"Let him go and play Amma," Mini said, "Does it matter if he does not eat, just for today?

"It matters, Mini." Amma replied. "You know Apu, your body is like a factory. It takes in food to make energy, repair the worn-out parts, to help you grow and keep you safe from illness. Remember, you learnt all this last year!"

"So what if he misses just one meal?" Mini wanted to know. "He had breakfast early in the morning. That should give him energy and everything else."

"Ah, Mini, that energy does not last very long. Now put your ear close to Apu's tummy and listen! Do you hear a rumble? That's his tummy saying it is empty and wants more food."

Mini listened and had so many questions to ask, "What is this rumbling sound? Where did his breakfast go in just four hours? What happened to that food inside his body?"

"I know what happened," said Apu, smiling impishly. "It turned into shi shi, you know, the stools that we pass out every morning!"

Now Mini was really curious, "But Amma, how did the food give energy?

And our stools look and smell so different from the food we eat!

Something must be happening inside our body."

"You'll find out," said Amma, "So many things happen inside our body all the time. Let's find out what happens to our food."

Classroom experience

I had explained the phrase 'repair the worn-out parts' in *Small Science Class 3*, but after one year I found this idea still unclear to many students. I explained that just as footwear and clothes get worn out with use, so does the body. Suppose we did not wear chappals wouldn't our feet get worn out instead? These worn-out parts are rebuilt with food. Internal as well as external organs get worn out. Besides, the child's body has to grow in size too. That is why we need body-building foods.

Students explained the difference between food and faeces - in colour, smell, shape and consistency. They realised that food undergoes major changes inside the body. (They also remembered other words for "faeces" - "stools", "excreta", "faecal matter", etc.) Several difficult questions arose during this discussion. Though I could not answer the questions immediately I was glad to see students thinking about bodily functions in a scientific way, without embarassment.

Whatever the colour of the food, why are faeces always yellow? Why do they smell bad? (See pages 306 and 310)

Why does the stomach rumble? (See Activity 3d, page 303)

ACTIVITIES

1. What happens to the food we eat? (2 periods + home-work; TB p. 86)

The food we eat cannot go straight to all parts of our body. It first travels along the **digestive path**. Along the way food gets churned and mixed with digestive juices. The juices help break it down into smaller and smaller pieces.

These tiny particles and water leave the digestive path and go into our blood stream. The blood carries them to all parts of our body. They are used to keep all parts living and growing.

Waste food that we do not need continues along the digestive path. It is finally thrown out through the anus.

After studying these pictures (on pages 86-87 in the TextBook), complete the exercises on pages 137 and 143 of your WorkBook.

What is digestion?

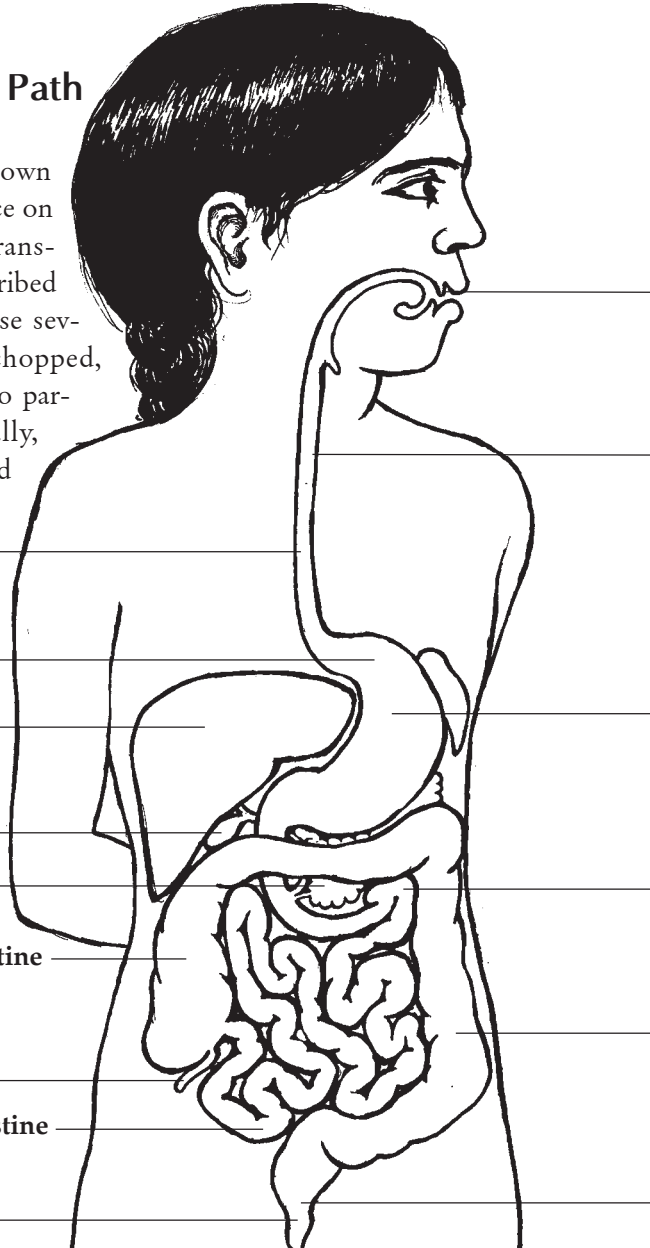
In digestion large molecules food are broken down into small ones which can dissolve in the blood. Some parts of foods, like simple sugars (glucose), vitamins and minerals, do not need to be broken down. They dissolve in water, so can be directly absorbed into the blood and carried to the rest of the body. However the very large molecules of complex carbohydrates, fats and proteins do not dissolve in water. They need to be broken down into simple, soluble substances with molecules small enough to pass through the walls of the small intestine into the blood.

Classroom experience

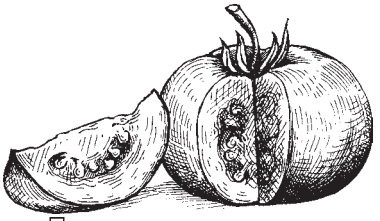
Initially on questioning children I found that many of them held the simple view that the food we eat goes directly, or via the stomach, all over the body. The idea of an enclosed tube or digestive path was new to them. I told them the story of William Beaumont, a U.S. Army surgeon who in the 1820's actually watched what was happening in the stomach! He worked with a patient who had suffered an accidental shotgun wound in his stomach. The wound healed leaving a hole in the abdominal wall that went right through to the stomach. Beaumont could insert tubes into the hole to extract samples of the stomach contents. He found that quite a few changes were happening to the food inside the stomach.

The Digestive Path

The picture shows the digestive path (also known as the alimentary or food canal). The sequence on page 295 shows how a tomato might be transformed as it travels down the path. As I described this process I encouraged students to visualise several action-words and phrases like, torn, chopped, ground, mixed, pushed, churned, broken into particles, passed into blood stream and finally, thrown out. The word 'churn' was introduced as in: 'curd is churned to make buttermilk'.



What happens to a tomato when you eat it?



Food is torn, chopped, ground, and mixed with saliva in the **mouth.**

mouth
5-30 seconds

The **food pipe** carries food to the stomach.

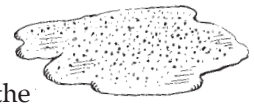
food pipe
10-15 seconds

Food is churned, mixed with digestive juices, and broken into smaller and smaller pieces in the **stomach**.

stomach
3-5 hours

In the **small intestine** food is broken into particles so small they pass into the blood stream.

small intestine
3-4 hours



Broken down food particles are carried to all parts of the body by the blood stream.

Undigested food and water goes into the **large intestine.** Liquids pass out of the large intestine into the blood stream.

large intestine
8 hours - 3 days

Solid food waste (faeces) is thrown out through the **anus**.

Waste liquids are finally thrown out as urine

Details of the digestive process:

In the mouth: The cutting teeth or 'incisors' at the front of the mouth bite off pieces of the food, the 'canines' help tear and chop it into pieces while the 'molars' at the back of the jaw grind it into a smooth paste. While the teeth are tearing and grinding the food it is wetted and softened with saliva and worked into a ball by the tongue.

Saliva contains the enzyme 'ptyalin' which changes starch into sugar. The three pairs of salivary glands in the mouth produce 1 to 1.5 litres of saliva daily. Saliva also contains a slimy mucous which helps food slide down the gullet.

Fine particles of ground-up food offer a larger surface area for effective action of digestive juices all along the food canal. The action of chewing might take between 5 and 30 seconds depending on the kind of food. If we chew food hurriedly, the starch is not properly digested by the saliva. The other juices too cannot act well on these lumps of starchy food, which stay for too long in the stomach, causing acidity and discomfort.

When we swallow, a small flap moves to close the the wind pipe which is next to the gullet. If food accidentally lands on the flap or enters the wind-pipe we cough and jerk it away. The food is squeezed down the gullet by the contractions of the gullet muscles till (in about 10-15 seconds) it reaches the stomach.

In the stomach: Food is mixed with gastric juice which is produced by many tiny glands in the lining of the stomach. About 2-3 litres of gastric juice is poured into the stomach daily, thus the contents of the stomach are quite liquid.

Gastric juice is made up of 'pepsin' which begins the digestion of proteins, 'rennin' which clots milk so that it remains in the stomach for some time, and 'hydrochloric acid' which provides an acidic environment needed

for the pepsin to act. Hydrochloric acid also kills most of the bacteria thus preventing food from fermenting in the stomach and also protecting us against disease.

Regular contraction and relaxation of the walls of the stomach helps to churn the food. The partly digested food is then squeezed into the small intestine.

A normal meal stays in the stomach for 4-5 hours. An interval of 5-6 hours between meals gives the stomach enough time to complete its work and take a short rest before dealing with the next meal.

The small intestine: It is a long narrow tube folded into many loops. In the first part, called the duodenum, the food is mixed with 'bile' (produced in the liver and stored in the gall bladder, helps digest fats, gives the characteristic colour to faeces) and pancreatic juice (produced in the pancreas, continues the digestion of starch, proteins and fats). The food stays in the small intestine for 3-4 hours. Digestion is completed by intestinal juice which is secreted by glands in the small intestine.

The outer wall of the small intestines is covered with a network of blood vessels. Most of the useful part of the digested food passes through the walls of the small intestine into the blood. This part of the food is used by our body for energy giving, body building and disease fighting.

The remaining part, which is mainly waste matter, goes into the **large intestine**. Here the excess water, with some salts and vitamins, is absorbed into the blood. When this blood passes through the kidneys, the excess water, along with other waste products formed in the body like urea, is separated from the blood and collected in the urinary bladder. The excess water is thus finally thrown out through our urine and some also through sweat.

Meanwhile the solid parts might stay in the large intestines for between 12 to 48 hours before they are thrown out as faeces. If the waste stays in the intestines for too long, more water is absorbed from it and the faeces become harder.

2. Digestive juices break down food (2 Double periods; TB p. 88)

In your mouth food is torn into pieces and ground up by your teeth. Your tongue helps mix up food and move it around. Food is also mixed with **saliva** (spit) in the mouth. Saliva is a **digestive juice** that helps to break down food into smaller pieces.

a. Chew a piece of bread, roti or cooked potato for 2-3 minutes. Describe the change in taste (WorkBook page 137).

Flour and potato contain a lot of starch. Saliva changes starch into something else. Can you guess what it is?

If you chew your food well, the saliva will digest it well!

Classroom experience

Students had brought roti, bread or rice. Those who did not have their own, or who had it in their tiffin boxes already sweetened with jam etc., took a piece from their partners. Interestingly, many students did not notice the sweet taste on chewing bread and rice. They seemed to think of 'sweet' as in *mithai* or sugary drinks. The change in taste was more noticeable for *bhakri* (coarse roti made from *jowar* and *bajra*), than for white bread and rice. I asked students to chew a piece of cucumber for contrast, to see that it did not change in taste; some remarked that cucumber turned bitter on chewing.

Conceptual problem

A similar problem with noticing sweetness occured later (Chapter 10 *Did you know*) while explaining that curd was made by bacteria consuming the sugar in milk and giving out a (sour) acid and carbon dioxide. I asked students to taste sweet milk which later changed into sour curd. Here too (a) students did not notice on their own that plain milk without added sugar actually tasted sweet, and (b) they judged curd which was just formed as 'sweet' rather than 'sour'. I realised then that sensation of taste is subjective and partly determined by comparison with other tastes, which could differ according to ones' experiences.

b. Iodine turns starch blue or black. Take small quantities of banana and other fruits, flour, groundnuts, roti, milk, cooked rice, potato, butter, bread, cabbage, different grains, cooked egg, tomato, biscuit, etc. Test if these foods contain starch by putting a drop of iodine solution on them (Work-Book page 138).

Practical hints

Tincture iodine from the chemist's shop gave a black colour when put on bread. A drop of this iodine diluted with 10 drops of water gave a blue-purple colour on bread.

Observation and interpretation

Another interesting experience: the whole cereal and pulse grains did not show a blue colour with iodine. Why did a grain of wheat not turn blue with iodine but bread made from wheat did? One student wondered if it was the water in bread that made iodine blue, others thought it had something to do with the wheat being ground-up. The latter guess turned out to be correct - the crushed grain showed blue colour. We concluded that the outer cover of wheat (and other grains) did not contain starch while the inside did.

Classroom experience

The following foods showed a blue colour with iodine: flour, bread, roti, cooked rice, potato, papad, all the cereals and pulses we could find like, wheat, rice, corn, jowar, bajra, ragi and different dals (one crushed grain of the cereal or pulse was sufficient for testing), biscuits, apple and banana.

The following did not show a blue colour with iodine: tomato, orange, watermelon, milk.

c. Scrape or mash a piece of raw potato. Mix it with 3-4 teaspoons of water. Let the bits of potato settle. Pour out the cloudy mixture. Test a teaspoon-ful of this mixture for starch (WorkBook page 138).

Put another teaspoonful in your mouth. Roll it around in your mouth for 5-6 minutes. Then spit it out into a glass and test it for starch (WorkBook page 138).

Practical hints

For this experiment to give the expected results, some precautions should be taken:

• Before the experiment wash the glass well to remove any starch sticking to the inside.

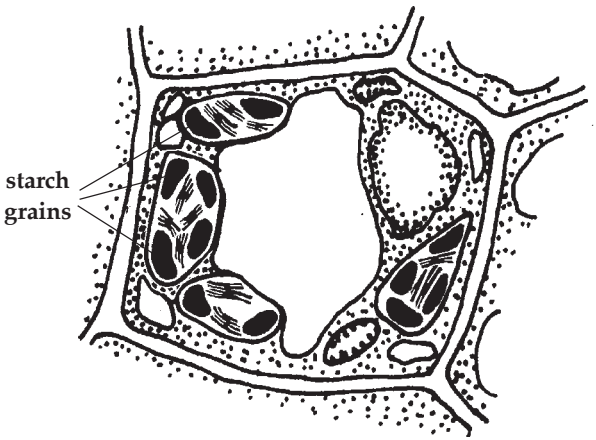
• Saliva cannot digest large quantities of starch in a single mouthful. So use only a light cloudy starch suspension. Do not let any scraps of potato remain in the liquid.

• Swish the liquid around in the mouth for 5-6 minutes to allow all the starch to get digested.

• Even with these precautions the digestion of starch may not be completed. In that case you might find a light blue colour in the partly digested solution compared to a dark blue colour in the original.

Classroom experience

In fact most groups did get a light blue colour. They concluded that some starch was still remaining. Normally this remaining starch gets digested in the stomach or the intestines. At the end of the lesson we viewed some of the cloudy solution with iodine under a microscope to see grains of starch.

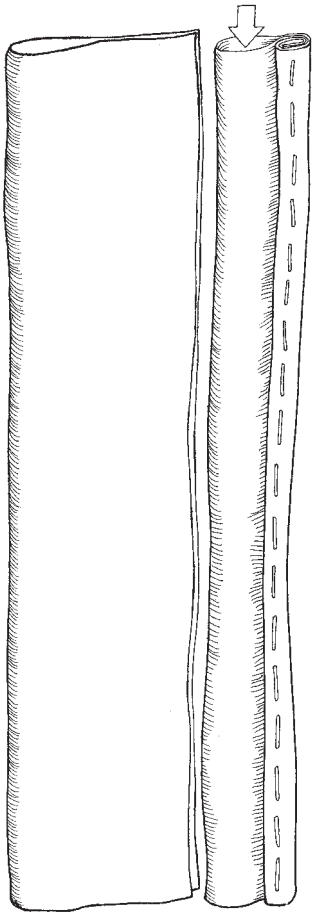


starch grains in a plant cell under a microscope

3. How food goes through the digestive path (Double period + homework)

Materials needed

(Per group of students) Two to three used plastic bags e.g. empty milk pouches; cellotape, stapler or needle and thread; half a ripe banana; cotton cloth about 20 cm square; plate and spoon.



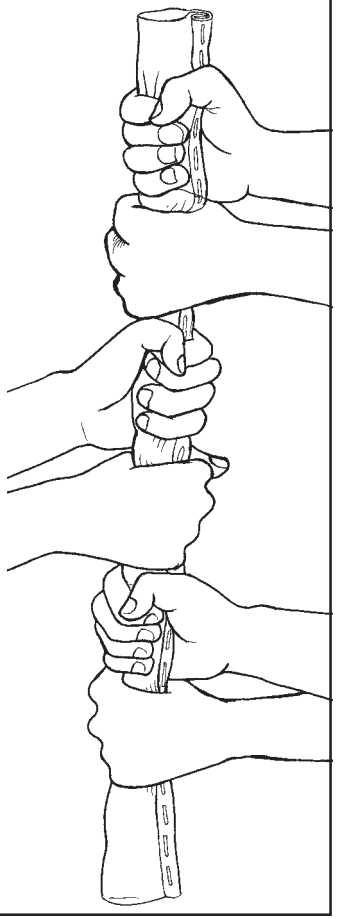
a. When you swallow, food goes down your food pipe (TB p. 89).

Make a model of your **food pipe**: Cut out a long piece from a plastic bag (about 20 cm wide and 40 cm long). Fold it in half lengthwise, roll up the edge and sew or staple it to make a long tube.

Put a squashed banana into one end of the tube. Three of you hold the tube with your fists. Do not leave gaps between the fists. Pretend your hands are the muscles of the food pipe.

By clenching and opening your fists, try to move the lump of banana from the top of the tube to the bottom.

This is how food moves through the food pipe, and also through the small and large intestines (Work-Book pages 139-140).



Classroom experience

Two used plastic milk pouches opened out, joined together and rolled into a tube made a model of the food pipe. Students needed some practice to squeeze in coordination so that the banana travelled in one direction and did not come out from both ends.

b. Make a model of your **stomach**: Put the banana from your model food pipe into a clear plastic bag along with some water. If you like, add a little leftover cooked food like rice, dal, sambhar or soft *subji*.

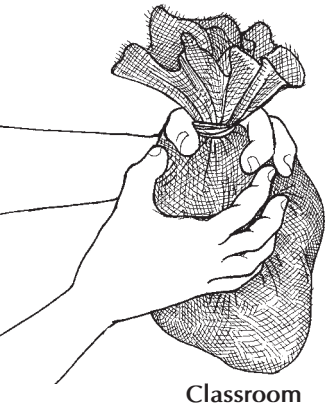
Tie up the mouth of the bag, being careful not to leave much air in the bag. Now pretend your hands are the stomach muscles.

Try to mix the food with your hands in the same way it might be churned by the stomach muscles.

What happens in your real stomach that is not happening in your model stomach?

Classroom experience

The model stomach was a plastic bag held under the model food pipe so that the mashed banana dropped into it. Students added some water into it to simulate digestive juices. They churned the food by squeezing the bag with their hands. (The model is incomplete because it has no digestive juices to chemically break down the food.)



c. Make a model of your **intestines**: Put the wet food from the stomach model into a piece of cloth. Tie up the cloth and gently squeeze it.

What comes out and what remains inside?

How is this similar to what happens in the small and the large intestines? How is it different?

Classroom experience

The liquid that oozed out of the cloth gave a crude idea of absorption of nutrients and water through the walls of the intestines. Actually in the body these liquids pass into the blood. Some students mistakenly thought that the liquid passing out of the large intestine was urine. I told them this was wrong, that urine was separated from the blood later in the kidneys.

d. Listen to the sounds in your digestive path: Put your ear on your partner's belly and listen carefully for two minutes. What do you hear? Try this before and after a meal. Imagine what might be making these sounds.

Classroom experience

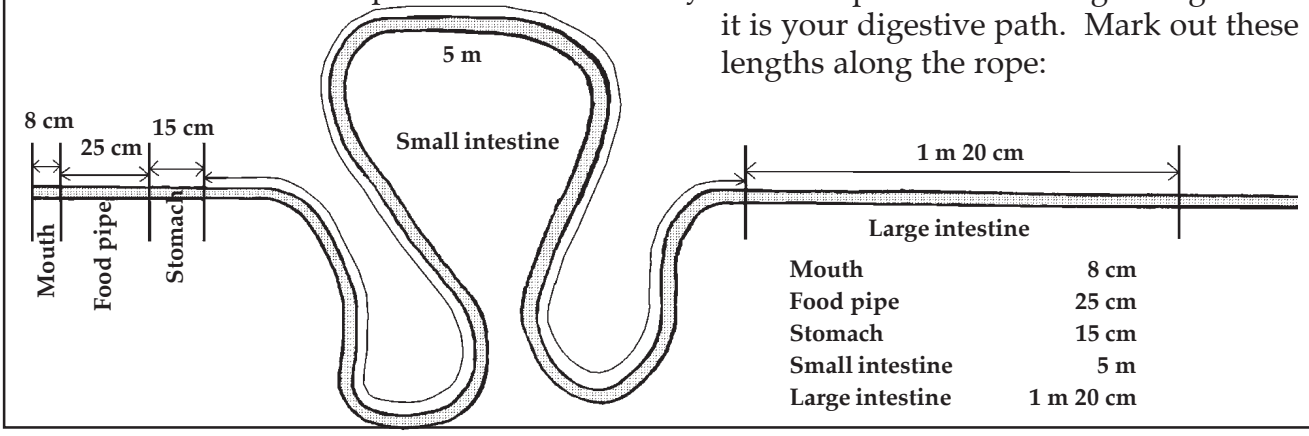
With quiet and concentration most students could hear sounds in their partner's stomach. These were low crackling or growling sounds, sometimes resembling the crumpling of paper.

Why does the stomach rumble?

The muscles of the stomach normally contract and relax rhythmically about three times per minute. But if the stomach has been empty of food for a long time, the contractions last for as long as 2-3 minutes. Gases and digestive juices slosh around making a sound which is amplified by the emptiness of the stomach (much, as we saw in Chapter 3, Activity 7, the sound of a musical instrument is amplified by a sound box).

4. How long is the digestive path? (Double period + home-work)

The digestive path is much longer than our body. The longest parts are folded up to fit inside our body. Take a rope about 7 m long. Imagine that it is your digestive path. Mark out these lengths along the rope:



Mouth	**8 cm**
Food pipe	**25 cm**
Stomach	**15 cm**
Small intestine	**5 m**
Large intestine	**1 m 20 cm**

What is the total length of this digestive path? Measure the rope and check the sum (TB p. 90).

Draw the outline of your friend's body on the floor with chalk. Place the rope inside the body outline in the same way the digestive path is folded up in your body (WorkBook page 140).

Classroom experience

The activity helped to reinforce the measures of length (centimetres and metres), provided students practice in measurement and calculation, and finally gave an idea of the surprising length of the digestive tract, particularly the intestines.

> Arranging the string inside the body I wondered, why don't the stomach and intestines collapse out of shape inside the abdominal cavity? The organs in the abdomen are all packed together closer than we realise from the separate diagrams we see of each of the body systems. The stomach and intestines are held up by surrounding muscles and are also attached to the body wall by thin sheets of connective tissue containing fat, blood and lymph vessels and nerves. The total length of the living digestive tract is about 7 metres. After death when the parts lose their elasticity they can be stretched out to 9 metres.

Think! Think!

Every organ in the digestive path has a different shape. The food pipe is a short tube, the stomach is bag-shaped, while the intestines are long, coiled tubes. What would happen:

a. If the food pipe was coiled?

b. If the stomach was a straight tube?

c. If the intestines were short and straight?

Classroom experience

Here students had to relate the structure of the organs with their function. Most students gave reasonable answers for the stomach (eg. that a tube-like stomach could not hold much food). Fewer could imagine that food would take unnecessary time to go through a coiled gullet; the advantage of long intestines (more surface area for digestion and absorption and coiling to fit inside the body) was even harder for students to express, but having done so, it seemed to help their understanding. (The optimal shape of our organs has come about through evolution, an idea too subtle for Class 4.)

5. How food changes inside the body (1 period + home-work; TB p. 91)

You have seen how food changes inside the mouth. Do you know how food looks in the stomach and intestines? (WorkBook page 141)

Aim of the activities

In Class 4 students have no notion of chemical transformation. After learning about digestion they are often left with the impression that food is just mashed up in the body, i.e. physically broken into small pieces. They do not realise that digestive juices play a role and that food is transformed into other substances. The observation of partly-digested food in vomit and in the stools is meant to draw attention to this transformation.

It might also help to recall foods undergoing other kinds of chemical transformations: eg. ripening of fruits, cooking, fermenting or the results of adding dilute acids like lemon, vinegar and tamarind which lead to decolorisation and softening of foods, as in pickling.

a. Some time when you were sick you might have vomited food. This partly digested food comes from your stomach, and sometimes also from your small intestines. Describe how it looked and what kind of taste it left in your mouth.

> Sometimes after excessive eating or drinking one might feel a burning sensation in the chest. This sensation is due to the contents of the stomach, mixed with the acidic gastric juice, splashing up into the food pipe. In vomiting, the partly-digested food in the stomach as well as the small intestines might be

thrown out. The terrible smell and taste of vomit is due to butyl acid which is produced in the small intestine. Since sugars in the food are either directly absorbed or quickly digested, vomit does not taste sweet.

b. What is the colour of your stools? Does this colour change from day to day? Notice the colour on the day after you have eaten green leafy vegetables, beetroot or a lot of tomato.

Think! Think!

People sometimes say that if you swallow a seed, "a tree will grow in your stomach and its branches will come out of your ears!" Is this possible? Why or why not?

The colour of our stools (faeces) is predominantly yellow due to the presence of bile bigments which are produced from the breakdown of worn-out red blood cells in the liver. Faeces contain waste products of digestion as well as undigested foods. In some digestive disorders more undigested foods might be found in stools. Even normally in stools of babies, undigested foods like carrots can be seen. Some students had noticed seeds of bhindi and pulses in their stools.

6. Other animals have to digest food too! (1 period + home-work)

These are pictures of digestive paths of some other animals.

On pages 141-142 in your WorkBook draw arrows to show the path of food.

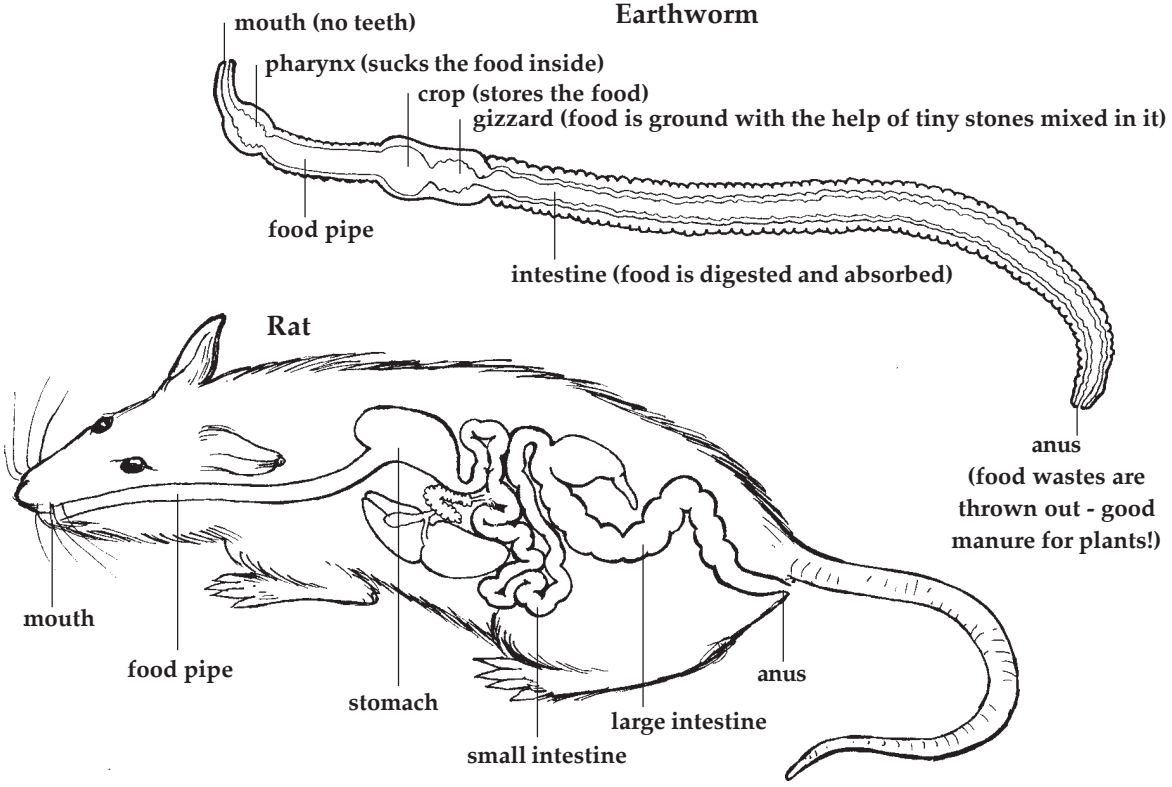
Which of these animals have a mouth and an anus?

Which of them have a stomach?

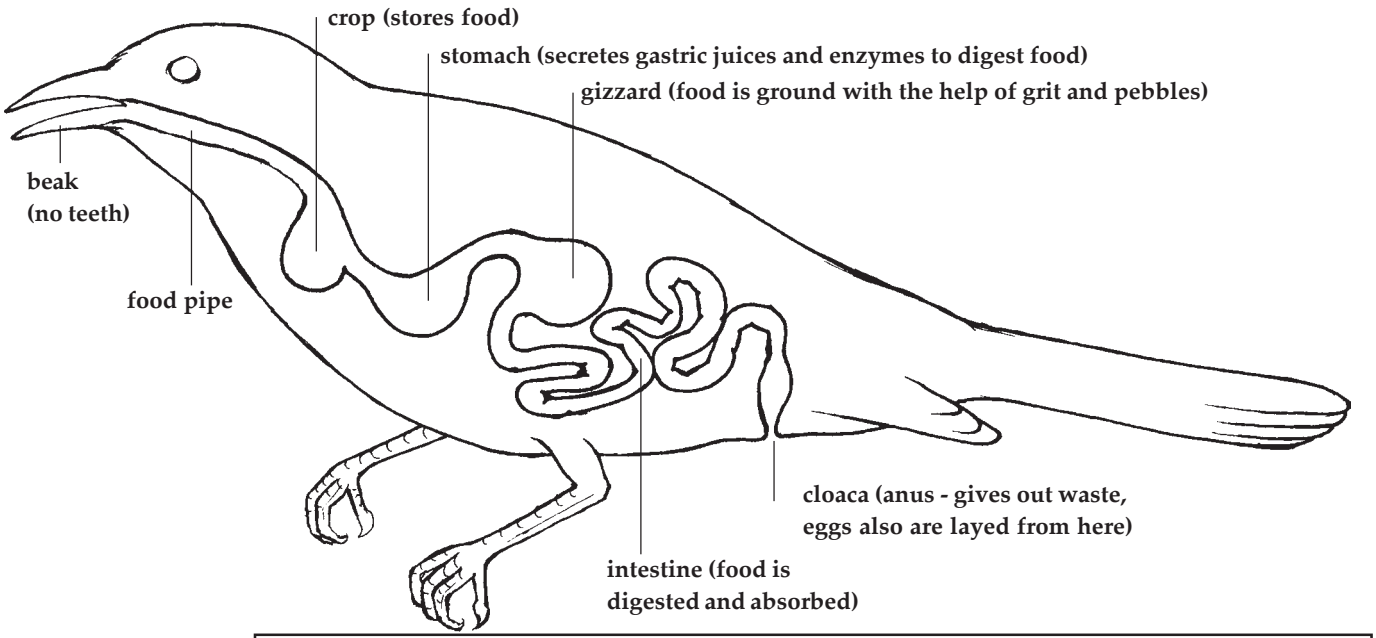
The food canal of which animal looks most like our own?

Bacteria and fungi do not ingest food. They give out digestive juices. The food is digested outside their body and then absorbed into the body, while wastes are given out. An amoeba has no fixed mouth or anus. It ingests food anywhere into its body and gives out wastes from any point. Flatworms have a single hole for taking in food and giving out wastes.

The pictures on page 92 in the TextBook show the digestive path in some higher animals. Of these the earthworm's system is the simplest.



Bird



Know these words

fermentation, digestion
food canal (another word for the digestive path)
mouth, stomach, small intestine, large intestine
saliva, digestive juices

EXERCISES (10 periods + home-work; WB p. 142)

Act it out

Reinforcing the information about digestion

1. Act out digestion. One student each could play the role of an organ like, the mouth, teeth, gullet (another word for "food pipe", stomach, small intestine, large intestine and anus. A round piece of paper could be the roti. Pass the roti along this 'digestive system'. Act out what happens to it.

Classroom experience

This activity was fun and gave scope to students' creative play-acting ability. In the course of going through the 'food canal' (digestive path), the paper was torn into many small bits. The minute shreds were 'sent' from the small intestine to the rest of the body while the larger ones were sent out through the anus.

Interesting question (WB p. 142)

1. In the picture on page 143 in your WorkBook fill in the missing parts and add the missing labels.

Classroom discussion (WB p. 144)

1. In what ways does food change inside our body? Suppose food remained as it was. Could it be used by the body? Why or why not?

See "What is digestion?" on page 293.

2. Suppose you put some mashed up food in a bowl, added some of the digestive juices produced inside our body and mixed it well. Would the food in the bowl get digested? Why or why not?

Students' alternative conceptions

This question was taken up with Activity 2. I was surprised when the students unanimously insisted that digestion could not take place outside the body. They felt that digestive juices were not sufficient, that something else inside the body was needed - perhaps the warmth of the stomach, or some mysterious life-force! I challenged their ideas, leading to a lively debate. Someone suggested that in Activity 2 c. (digestion of starch by saliva), rather than swirl the potato solution in the mouth, we should mix it with saliva inside a glass.

3. Does digestion occur while we are asleep? Why do you think so?
4. What will happen if we eat more food than we need? Will we get extra energy or become very strong?

The functioning of the digestive system is regulated by the brain, sometimes via the hormonal system. Signals from the stomach to the brain tell us when it is full and the bain signals that we should stop eating. Sometime we ignore these signals. If the stomach is too full, digestive juices cannot properly act on all the food.

5. Have you had indigestion? What might have gone wrong with your digestion then? Have you ever noticed any gas coming from your stomach or intestines? How could gas get into the digestive path?

Indigestion could be due to eating too much, eating foods which are difficult to digest, or food infected with illness-causing microbes (see page 231).

Gas in the digestive tract: If we eat too fast we are likely to swallow air with the food. This air comes up through the gullet as a burp during or soon after the meal. Babies tend to take in air like this when they suck milk. We have to hold them up after a meal so that the air bubble can come up.
Gas in the intestines is produced by microbes. It is formed if food remains in the intestines for too long, as may happen in indigestion. Some foods like beans, cabbage, onion and turkey are particularly effective for the growth of gas-producing microbes.

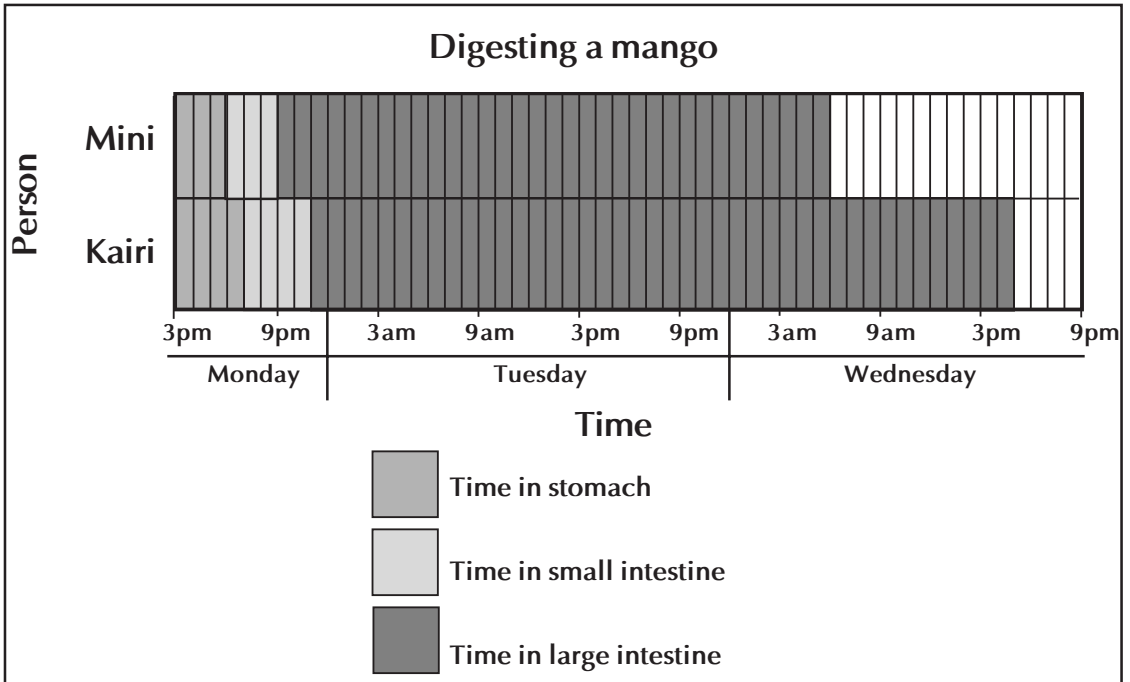
What's the same? What's different? (WB p. 145)

1. Is our digestive system similar to a kitchen grinder? How? How is it different? What things happen to the food in the digestive system but not in the grinder?

Figure it out (WB p. 145)

Quantitative thinking

1. Mini and her friend Kairi ate a delicious mango at 3 pm on Monday. This graph shows how long it took them to digest the mango.



Look at the graph and answer these questions:

a.Where was the mango at 4 pm on Monday in Mini's digestive path?

Stomach

b.Where was the mango at 4 pm on Monday in Kairi's digestive path?

Stomach

c.Where was the mango at 10 pm on Monday in Mini's digestive path?

Small intestine

d. Where was the mango at 10 pm on Monday in Kairi's digestive path?

Stomach

e. Did Mini and Kairi both take the same amount of time to digest the mango?

No

f. How many hours did it take each of the girls to digest the mango?

Mini - 39 hours; Kairi - 50 hours

Classroom experience

Most students answered questions a., b. and e. correctly but had trouble with c., d. and f.. They found it helpful to describe the situation in words, counting each line on the graph, pointing out the morning, evening and night times, the change of days etc.. The problem also gave students an idea of how much time food might stay in each portion of the digestive tract. The times might vary a little depending on the person, whether they were active or resting, what else they had eaten along with the mango, and so on.

Play with words (WB p. 146)

1. Mini wants to give Apu a crossword puzzle to complete. She found the crossword puzzle shown on page 146 of the WorkBook in an old newspaper. Someone had already completed it, but some of the clues were missing. Help Mini write clues for the crossword puzzle.

Classroom experience

Only a few students had experience of solving simple crossword puzzles. I encouraged them to construct clues of different kinds, say describing the structure of the organs or what happens inside them, combining two words into a single clue (as in "Food is __ inside the __"), even an anagram like, "I go send it" for "digestion".

After constructing the clues they could draw the crossword grid and give it to someone else to solve. Copying the grid was a fairly challenging exercise.

Ask a question (WB p. 147)

1. Ask questions about digestion of food. Think of how you will try to find the answers.

Students' question:

Is cooked food easier to digest than raw food? Why?

This student liked to eat all vegetables raw but her mother did not let her, saying they were difficult to digest; that if she ate too much of these raw vegetables she might get a stomach ache.

a. Cooking kills any disease microbes and parasitic worm eggs which might be in the food.

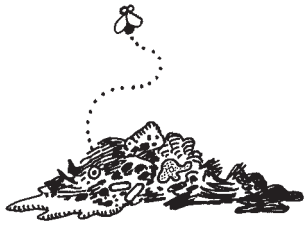
b. Cooking partly breaks down food - a job which starts in the kitchen and is further carried out in the digestive system.

Cooking breaks down the cellulose cell walls of vegetables. Though the cellulose itself is not broken down, the tough fibres surrounding the cells get softened. The plant cells burst open and so do some of the cell's contents, for example, starch grains. As a result, digestive juices in the body can act on the cell contents more effectively. When meat is cooked, the tough bundles of muscle fibres break up, making the meat easy to chew and thus digest.

c. Finally, cooking brings out the flavour of food making it appetising and helping to release digestive juices effectively.

DID YOU KNOW?

Many seeds are dispersed by birds who swallow them and pass them out through their faeces. Cows and goats also eat and pass out undigested seeds which grow into new plants.



CHAPTER 10

What is thrown out

Where our food goes

Aim of Activities 1-4

The introductory Activities 1 a.-d. make the point that we eat only a small part of any food, plant or animal. We need to think about the parts that we throw away.

1. The parts we throw away (2 double periods; TB p. 96, WB p. 148)

a. Look again at the pictures of food plants on pages 119-121 in your WorkBook.

Which parts of each plant do we **not** eat? Why do we not eat these parts?

Leaves and stems, unless very tender, are largely made up of cellulose. Digestive juices of animals cannot break down cellulose. But herbivorous animals like cows, goat and deer do eat grass and stems while tiny termites even eat wood! Digestion of stems and wood is done by **microbes** that live in the digestive paths of cattle and termites. Juices given out by the microbes break down cellulose into sugars which can then be absorbed by the bodies of the animals. The microbes too absorb their share of the food. (Microbial decomposition will become familiar as we progress through this Chapter).

b. The pictures on pages 76-78 of this TextBook show harvesting, threshing, milling and polishing of rice. Which parts of the rice plant are thrown out at these stages? Find out if these parts are useful (WorkBook page 149).

At the time of harvesting, roots and parts of the stem remain in the soil. These are dug out or burnt while preparing the field for the next crop. If the field is left fallow these parts decompose, providing manure for the next crop.

After threshing, the discarded parts like stems and leaves might be cut up to make fodder and manure. Large leaves and hay are useful as thatching materials. The husk which is discarded in milling might be mixed with clay to make bricks - the husk burns in baking, making the bricks porous. The bran produced in polishing grain and refining flour is used to prepare food for us and other animals (see pages 257-258).

c. List some animals whose flesh we eat. Which parts of the animal do we **not** eat? Why do we not eat these parts?

Students' observations

The edible parts of animals are the muscles (or "flesh"). Parts usually not eaten are, eggshells, hard or soft external organs - horns, hair, skin, feathers, fins, gills, scales, eyes, bones - and internal organs. Some internal organs like liver, heart and brain, are commonly eaten, while digestive organs are usually not eaten (guess: why not?). A useful outcome of this discussion was that students could relate their experiences of eating meat with names of organs which they had learnt in school.

d. Find out how much garbage is produced in your kitchen in one day. Where does all this garbage go?

Students' observations

Except a few students who helped at home in lining the bin with paper or emptying out garbage, the others had not paid attention to the fate of their kitchen garbage. Now they estimated the volume of their daily garbage from the volume of the bin and to what level it was filled. We thought using weight as a measure might be more reliable (volume estimate would vary according to tightness of packing). But finally, we chose volume estimation because it was easier to carry out and also students had previous practice with it (Chapter 7, Activities 4 and 5 - pages 225-228).

Students found out whether their garbage was emptied out in a municipal bin (covered/ uncovered), a local pile or elsewhere, whether it was transported from there manually, by cart or by truck. I helped them to find out the later part, whether the garbage (perhaps in compacted form) was then taken to a dump, a landfill, or an incinerator. The

uses of food garbage - compost, biogas etc. - were discussed later (pages 325, 339-340, 130).

Think! Think!

In preparing food from plants and animals, we throw large parts into the garbage. Could these parts be useful in any way? Make your own guesses.

Linkage across topics

Several earlier discussions were recalled. In Chapter 8 students had learnt that plant and animal wastes could be used to prepare food for domestic animals. In *Ask and find out* in the same Chapter (page 285) they had found out that waste matter from plants and animals provides nutrients for the growth of plants (see info on *composting* and *vermiculture*). In Chapter 4, Activity 4b. (page 130) I had mentioned biogas plants where gases (particularly methane) produced in the decomposition of plant and animal wastes are used as fuel for cooking and lighting. The residue is used as manure. We discussed garbage disposal further in *Classroom discussion* and *Ask and find out* (pages 339 - 340).

2. Who eats our wasted food? (1 period; TB p. 96, WB p. 150)

Name some animals who eat the food that we throw away.

At the school picnic Mini and her friend ate bananas. They dropped the banana peels near some bushes. A goat passed by and ate one.

The other peel started to decompose.

Flies, beetles, ants, snails, millipedes, and earthworms ate parts of the decomposing peel.

A few weeks later: the peel had decomposed further.

Some months later the peel was almost completely broken down. Its parts had mixed into the soil and the air!

How did this happen? (WorkBook page 150)

Students' observations

The story of a the banana peel highlights the role of a number of larger animals who help to eat our wasted food. Besides the goat in the story, students mentioned cow, dog, rat, pig, crow and vulture as animals who live on food that we throw away. Beetles, snails, millipedes and earthworms were less easily noticed, while cockroaches, ants, flies and fruitflies were the insects most noticed by city students. In the wild the larger animals do an important service but close to human habitations they often create a nuisance by scattering garbage making collection difficult, besides spreading disease microbes (hence the need to keep garbage covered).

I told students that ultimately all parts of dead plants and animals decompose; hard parts like bones take longer to decompose. One student remembered that she had kept a beautiful dead moth in a box - and found after several months that the wings and body of the moth had crumbled into powder. The role of microbes in decomposition came through in the next two activities.

3. How microbes decompose food (2 double periods + continuing observations; TB p. 97, WB p. 150)

Microbes like moulds and bacteria are all around us. Any food has some microbes in it. Microbes from the surrounding air, water and soil get into it. Animals which come to eat the food bring some more microbes.

The microbes give out juices that break down the food. They use this food to live and grow. Very soon these microbes 'multiply' into more microbes. The wastes and gases given off by the microbes make the food look and smell rotten.

Weeks or months later the food has broken down completely. Where has it gone?

Classroom experience

Students had already learnt that 'decompose' means 'to rot' (see Chapter 4, Activity 4: 'Where do different gases come from?'). They also knew that different gases are produced during decomposition (I had mentioned names like carbon dioxide, methane, hydrogen sulphide, sulpher dioxide and nitrogen dioxide). These gases are formed by the breaking down of plant and animal matter.

Now I explained that the word 'decompose' means 'to break down'. The 'breaking down' is done by the action of juices (enzymes) produced by microbes. This is similar to what they had learnt in Chapter 9, that food is 'broken down' during digestion by the action of digestive juices (enzymes). Loosely one might say that the microbes eat or digest the food. In Activities 2 and 3 students were able to observe decomposition closely, and visibly see it as 'breaking down'. The meaning of the term 'multiply' was explained in Activity 4.

a. Take two plates, each containing a piece of roti or any other cooked food. Keep one plate covered and the other open. Each group should keep their plates in a different place: out in the sun, inside a room, or in a refrigerator. Observe over a few days.

Did any animals eat the food? Did the pieces of food change in any way? Is there any difference between the covered and uncovered foods?

Did you see anything growing on the food? You might see grey, black, green or yellow spots on it. This is a kind of mould. The mould is slowly breaking down and eating the food! Look at the mould with a hand lens. Smell it from a distance.

On this food there are also bacteria and other microbes that you cannot see.

Should you eat this food? Why or why not? Guess how this food might look after several months (WorkBook pages 150-151).

Students' observations

Besides the possibilities given in the TextBook, students suggested different places where they could keep the food: in the terrace or playing field (sunlight), shade, on the window-sill, in the warm kitchen, etc.. They kept one piece of roti and a sprig of *chawli* (amaranth) inside a plastic bag and another set uncovered. Sample observations:

What happened to the roti

In the classroom		On the terrace	
Covered	**Uncovered**	**Covered**	**Uncovered**
There were drops of water inside the bag. Mould (fungus) grew on the roti.	Dried up, no mould	Ants broke it into bits and carried it away (only some powdered roti and 5-6 ants remained in the bag)	Probably taken by a crow

The roti that dried up did not show mould. Mould (fungus) and other microbes need water and warmth to grow. Thus water and warmth speed up decomposition.

One student asked, if mould is a micro-organism, how is it that we can see it? I replied that we can see the mould only after it has multiplied to form a bunch consisting of 10-20 moulds along with their hair-like projections. We cannot see individual bacteria, but a bunch of 100,000 bacteria might be just visible as a tiny spot while 100,000,000 bacteria could be easily seen as a coloured patch - due to their sheer number as well as the juice secretions and their decomposing effect on the food (see next Activity: 'How bacteria multiply').

b. Describe the smell of a garbage bin. Did the garbage smell like this before you put it into the bin? What makes it smell now?

If you do not brush your teeth, does your mouth smell? Guess why.

Students' observations

Students had seen houseflies and fruitflies hovering near garbage (initially they did not distinguish between these and mosquitoes seen over stagnant water). I told them that

flies and other insects ate the garbage and they also brought in microbes. Other microbes came from the air or were already there on the food.

Some recalled the discussion in Chapter 4 (Activity 4: Where do different gases come from?) to answer why the garbage smells: microbes release gases in the process of decomposing food. Students realised that if garbage bins are not cleaned out and washed regularly, some decomposing food remains in them, making the bins smell bad all the time and causing a health hazard too.

All these ideas seem obvious. But I have found that unless they are clearly discussed, students memorise whole paragraphs of text like, "Food gets spoiled when bacteria and mould grow on it ... etc." quite meaninglessly without at all relating it with their own experiences.

> Food stuck to the teeth decomposes. Bacteria which live in the mouth feed on this food. They make acids which dissolve the enamel (hard outer layer) of the teeth, reaching inside and causing tooth decay.

c. Take four banana peels. Bury each peel on a marked spot in wet soil. Each week dig out one of the peels and observe it (TB p. 98).

What will you find in the soil when the peels have decomposed completely? Guess how many days it will take for the peels to mix into the soil and the air.

The decomposing peels add something useful to the soil! They get broken down into nutrients that can be used by plants (WorkBook pages 150-151).

Take care!

Wash your hands well after handling decomposing food. Some microbes growing on the food can make you sick. Some of them make poisons that can make you sick.

Practical hints

Ripe or over-ripe bananas are preferable as their peels will decompose faster. It might be better to bury the peels out in the open rather than in pots, as outdoors they would be exposed to natural conditions like sun, rain and a variety of large and small decomposers. If the weather and the soil are dry then the place where the peels are buried should be watered regularly. In damp soil with a lot of humus the peels might be fully decomposed in a week, while in extremely dry soil they would dry up and might take months or years to decompose.

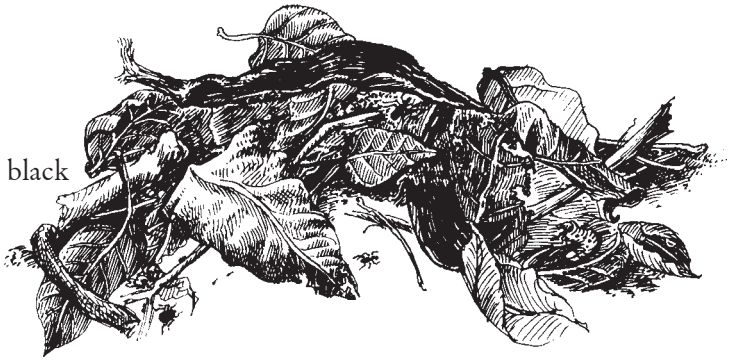
Classroom experience

We did this activity during the rainy season. After a week the banana peel was shrivelled and black with white mould and tiny beetles crawling around it. The next week it appeared broken into 4-5 pieces. Over the days the pieces became smaller and more numerous. Four weeks later only some black particles were seen. We would not have guessed that these particles were remnants of a banana!

Haiku inspired by decomposition

Death it can bring
that kind of mushroom; and, of course,
it's a pretty thing.
(Issa, 1762-1826)

A banana peel
dropped on falling leaves turns black
And then – only leaves
(Karen Haydock)



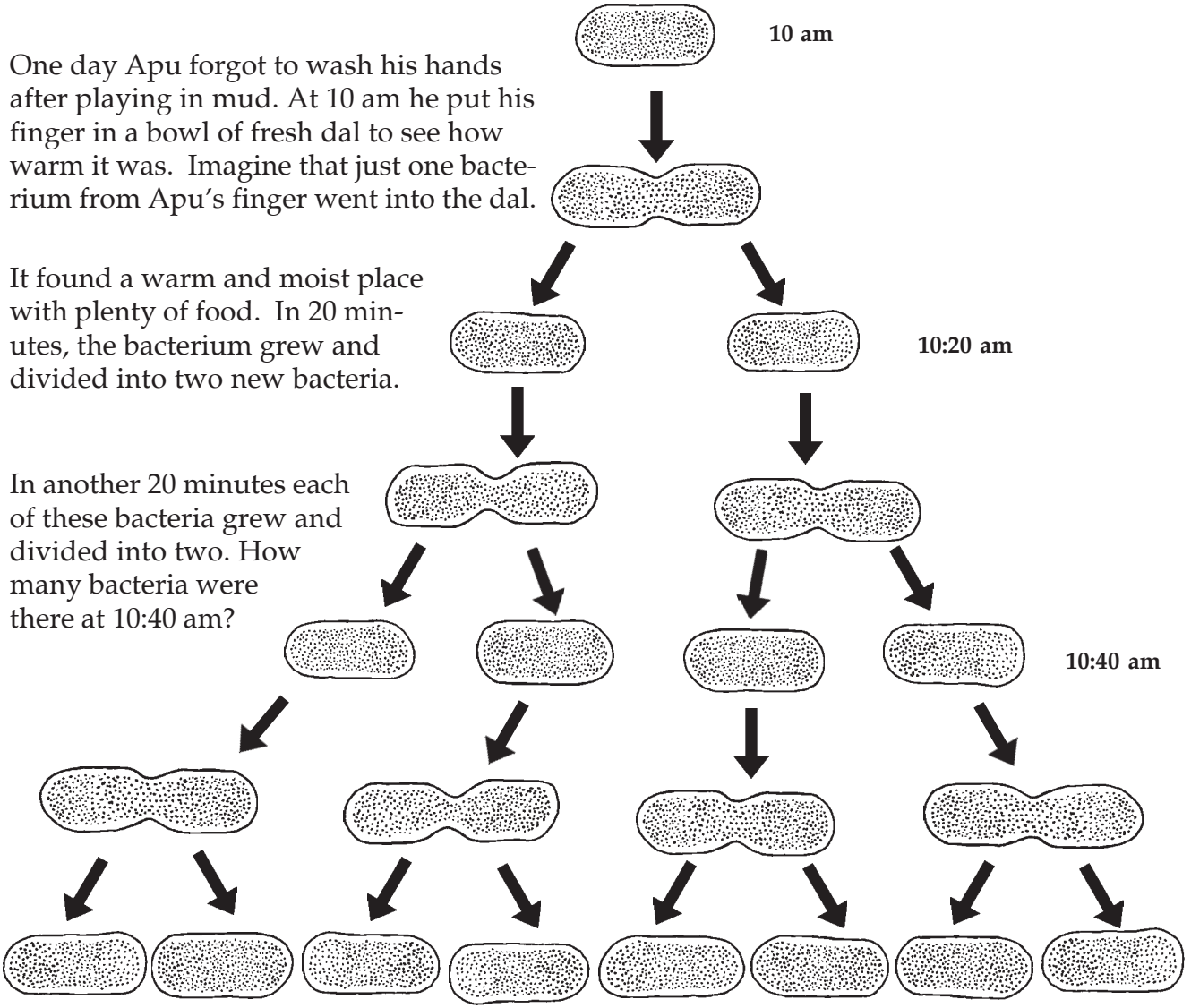
4. How quickly microbes multiply! (Double period; TB p. 99, WB p. 152)

Look what happened to this bowl of dal:

One day Apu forgot to wash his hands after playing in mud. At 10 am he put his finger in a bowl of fresh dal to see how warm it was. Imagine that just one bacterium from Apu's finger went into the dal.

It found a warm and moist place with plenty of food. In 20 minutes, the bacterium grew and divided into two new bacteria.

In another 20 minutes each of these bacteria grew and divided into two. How many bacteria were there at 10:40 am?



How many bacteria were there at 11 am?

Fill in the Table on page 152 in your WorkBook to show how many bacteria there will be if they continue to multiply so fast.

At 2 pm Mini found little bubbles in the dal. Where did the bubbles come from? What might happen if Mini ate the dal?

What should Apu have done first after he came back from playing? Was there a better way of checking whether the dal was warm or cold?

Conceptual problems

Students by now knew that bacteria and fungi are carried by the air. But when asked why the patch of mould (fungus) on a decomposing roti grows every day, some answered that more and more fungi of the same kind come from the air and stick to the roti. The idea of reproduction (of microbes) was surprising to all of them, and even after explanation many had trouble relating it to the pictures on the previous page showing "multiplication of microbes". I guess these concepts will develop slowly over time. Understanding of the exponential relationship between number and time is **not** expected now. (In a lighter vein: the bacteria `multiply' by `dividing'!)

Points to be conveyed

I explained that the dal left on the table would have decomposed anyway due to fungi and bacteria which were in it already, or which might have come through the air. Apu need not have started it by dipping his finger (washed or unwashed) into the dal. The story is meant to show that a. dangerous bacteria may be transferred through contamination of food, b. they multiply unimaginably fast and c. these large numbers of bacteria remain invisible to the eye; they may not even bring about any noticeable alteration in the appearance of the food. Food that has dangerous amounts of bacteria or toxins in it may look and smell just the same as good food! The number of cases of food poisoning, often mass poisoning on eating festival sweets or wedding feasts, that one reads about in newspapers are evidence of this fact. (Usually the causes are salmonella and botulism.)

Students realised that the dal might have been refrigerated to prevent it from going bad, but normal refrigeration (in practice, 12°C or higher) is effective only for a few days: microbes continue to multiply, though slowly.

Think! Think! (TB p. 100, WB p. 153)

"I don't like microbes!" Apu said. "They are dirty and smelly! They make us sick."

"Microbes are not dirty!" Mini replied. "They make everything clean. They eat garbage and break it down into smaller and smaller pieces that go back into the soil and help plants to grow!"

What do you think?

Microbes need time to do their work. If many people dump their food garbage in one place every day, all this food will take a long time to decompose completely. Flies, cockroaches and rats will eat the food and multiply. They will spread disease microbes everywhere.

What could we do with all this food garbage? (WorkBook page 153)

Points to be conveyed

The conversation between Mini and Apu uses informal language. The words "dirty" and "smelly" describe the partially broken-down food and the gases released from foods when microbes set to work on them.

In that sense both Apu and Mini are right. We have to recognise the danger of microbes and make sure that there are not too many of them in the air we breathe, the water we drink and the food we eat. But we should recognise that microbes are also our friends. Without them our garbage and faeces would continue to pile up around us. Microbes are essential to recycle our wastes and put the nutrients in them back into the soil to be used again.

Conceptually there are many difficult ideas here: the huge numbers and variety of tiny invisible microbes, their metabolic activity, the chemical decomposion of food, etc.. The microbes we fear are the relatively few types (say 100's) that cause diseases in humans. The rest of the ten of thousands of types are harmless. All microbes participate in breaking down the substances around them - some break down other microbes, and their wastes - all through numerous complex and wonderful processes.

The minimum aim here is that students think of how our garbage (and sewage, which is discussed next) should be managed so that the microbes get sufficient time and space to do their job of decomposition. For food garbage a local solution is easy: instead of piling up garbage, put it in a pit and cover with soil. Breeding earthworms in the soil will speed up decomposition. (See compost pit, pages 339-340.)

5. Microbes in our faeces (Double period; TB p. 100, WB p. 153)

You have learned to wash your hands well after you go to the toilet. You know that faeces should never come into contact with food or drinking water. Why do you need to be careful about all these things?

Why are faeces considered to be dirty? (WorkBook pages 153-154)

If you are a normal, healthy person, you may have as many as 100,000,000,000,000 microbes in your body! Most of the microbes are in your intestines and are harmless or even helpful. But there are also some kinds that could make you sick if there were too many of them.

Classroom experience

I began by asking students, could microbes get inside your body? In which parts? And, how do they get there? In Chapters 3 and 9 (pages 115, 127-128, and 310) we had concluded that there was air in the lungs and in the food canal (which are open to the outside), but that (except by an injury) air could not reach the muscles, blood or bones. The same argument applies to microbes.

Coming to the TextBook questions I tried to first get students to think about the reasons behind rules of hygiene, and then to tell them about the usefulness of microbes in our intestines. In the *Take care* section we discussed prevention and care of diarrhoea (this important information is repeated in *Small Science Class 5*).

> Most of the microbes that go in with our food are killed by digestive juices in the stomach. But a few reach the intestines where they multiply very fast.
> Our intestines - warm, moist with plenty of food, are a hospitable place for growth of microbes. In Chapter 6 (page 60 of the TextBook) we saw pictures of amoeba and some bacteria which could live in our intestines (see information on page 209). E. coli and some other kinds of bacteria help digest our food and produce some necessary vitamins. The large number of harmless microbes in our intestines do not allow the growth of harmful microbes (the latter are usually present in smaller numbers).
> If the number of harmful microbes becomes large, they make us sick. Some kinds of amoeba, E. coli and also the Staphylococcus, Salmonella and Cholera shown in the TextBook all cause various kinds of diarrhoeal diseases (see Chapter 7, page 239). A less common way that the microbes might harm us is if they accidentally entered the abdominal cavity or the blood (as happens in rupture of the appendix) - in that case they could be lethal.

Think! Think! (WB p. 142)

Have you ever noticed gas in your intestines? Where could this gas have come from?

This observation again refers the fact that microbes produce gases. Also see Chapter 9 *Classroom discussion* (page 310).

Take care!

Our faeces contain large numbers of microbes. Microbes can multiply very quickly in faeces. Faeces also attract flies that carry the microbes to our food. If we eat this food we might fall sick.

We must find safe ways to get rid of our wastes.

Billions of bacteria, fungi and protozoans are passed out with the faeces. If you remove the water, one-third of the weight of our faeces is made of microbes! Our urine (unless we have some infection) is sterile. But outside the body both faeces and urine are an excellent medium for the growth of microbes. Thus if faeces come into contact with food or drinking water they invariably spread diseases.

Diarrhoeal diseases

Students must have some experience of diarrhoeal diseases. They must be told that **these diseases can be prevented by ensuring that water and food are kept clean**. In Classes 3 and 4 they learn some good habits like drinking clean water, eating fresh food, washing raw foods in plenty of water, washing hands after passing stools and before eating, etc.

The most effective means of curing diarrhoea is Oral Rehydration Therapy (ORT). A simple rehydration solution is a mixture of 1 glass clean water + 1 teaspoon sugar + a pinch of salt. Several glasses of the solution should be prepared and given to the patient continuously in small amounts.

6. Where does our waste go? (3 periods; TB p. 101, WB p. 154)

a. Think about the place where you defecate. Do the faeces and urine stay where they are? Do you use a flush or pour water? Where do you think your wastes go?

Classroom experience

Students in my class all had flush toilets at home and they had seen other types in their villages and during trips out of town. I asked, what happens to stools flushed down the

toilet? Students imagined that the wastes must be carried away in pipes and finally let out into the sea. In coastal areas this is close to the truth.

> Two-thirds of Indian towns have piped water supply but less than 10% have an adequate underground sewage system. Ironically so, because the Indus Valley civilisation of 2500 B.C. was probably the first in the world to have houses with bathrooms and toilets. They had underground sewers with manholes and cesspools. There were wooden meshes at the mouth of the main drains to remove the solid wastes.
>
> Today with more people and huge volumes of sewage, we need much better facilities, but - the National Sample Survey for 1993 found the following toilet facilities available in Indian households:
>
> no latrine - 30.6 % service latrine - 7.4 % septic tank - 29.6 % flush system - 28.5 % others - 3.8 %

b. Which of the following pictures best shows the kind of latrine that you use? For each picture think about these questions:

What happens to the urine and the faeces? Is any part of the waste carried away from the place of defecation?

How much water is needed to clean the latrine after each use?

Would you expect to find flies and a dirty smell near this latrine? (Work-Book page 155)

Classroom experience

For each type of latrine I discussed where the waste goes, how to keep the latrine clean, how much water is needed to clean it, and whether there is a limit on how many people could use the latrine in a day.

i. Outdoor defecation (TB p. 101)

A lonely place in a field or jungle would be all right for outdoor defecation.

Take care!

Do not defecate near a pond, stream or well! (Why not?)

Do not defecate close to where people live! (Why not?)

If you defecate outdoors, cover the faeces with soil. This way, flies will stay away and microbes in the faeces will not spread. Under the soil, microbes will slowly decompose the faeces.

The decomposed faeces add something useful to the soil! They get broken down into nutrients which can be used by plants.

Classroom experience

All the students had at some time had to defecate outdoors. I first emphasised the hygeine and health aspects of this practice, especially washing and covering with soil, avoiding contamination of water sources, and remembering that faeces should not, even indirectly, have any contact with food and drinking water. (See Chapter 7, page 231 for illnesses spread via faeces.)

Students' responses

Next I turned to microbial decomposition of faeces. I asked, after you cover the faeces, will they remain under the soil (guess)? On the next day will they be there? After a week will they be there? After a month? A year? Students imagined that the faeces must slowly mix into the soil. Though they recalled decomposition of food garbage, they were not sure if faeces could decompose. (How could this dirty faeces be food for any living being?!) But finally they accepted the idea.

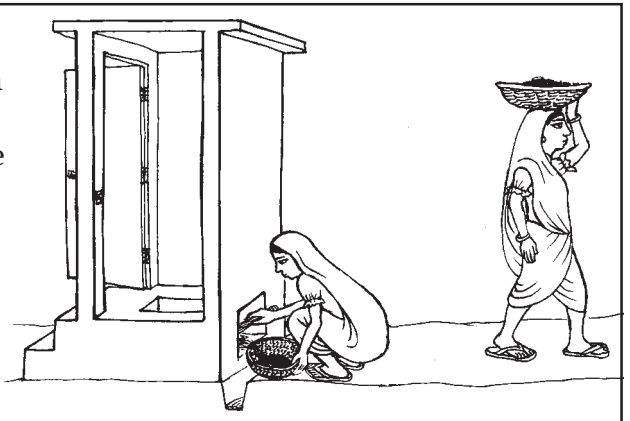
> The rate of decomposition of faeces in the soil would depend on the temperature, type of soil and moisture available. In warm, humid conditions with many soil organisms, decomposition would be faster. Eventually even the disease-causing organisms would decompose into harmless products!

Think! Think!

If only a few people defecate outdoors, there is no need to carry away the waste. What would happen if many people defecate outdoors every day around the same place?

This is similar to the problem of the quantity of garbage raised in the TextBook on page 100. A few people defecating outdoors, away from habitation and from sources of drinking water, would not cause a problem. Microbes in the soil and in the faeces would eventually decompose it. When people start living together in large numbers the disposal of their waste becomes a problem.

ii. Service latrine (TB p. 102)



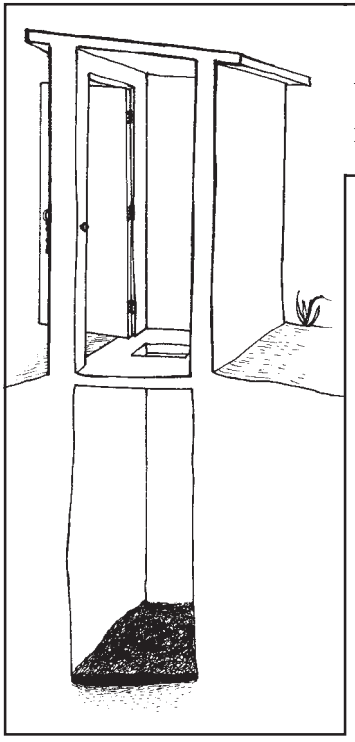
Who carries away the faeces from a service latrine? Where do you think they take it? What could be done with it?

Is this work dangerous? Why? Who would like to do this work?

The government has said that service latrines are unhygienic. The people who carry the faeces have to do inhuman work, and such latrines should not be allowed. What do you think?

The waste from a service latrine falls into a chamber from where it is swept out manually. Sometimes there is a bucket or basket inside which is carried away and the waste dumped in a field. After composting it might be used as fertiliser.

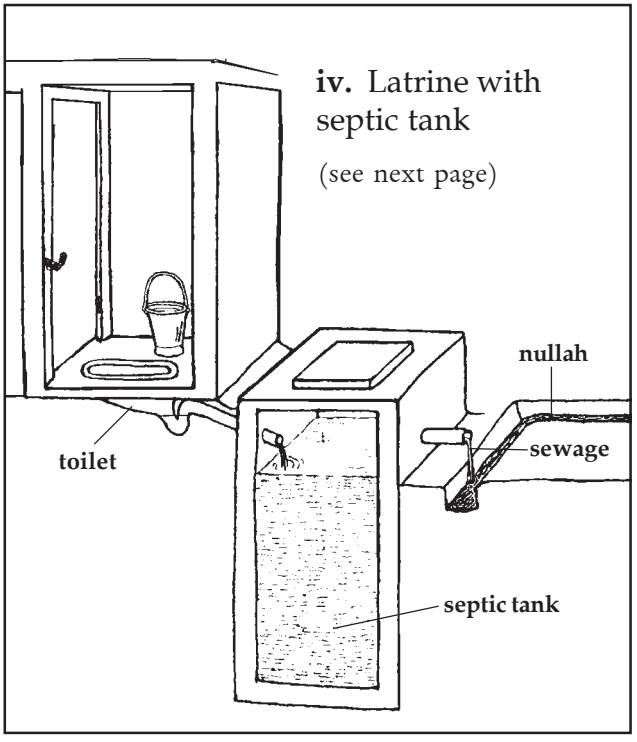
The work is done by the lowest caste of people in India, the 'bhangis' or scavengers; it is one of the most demeaning and unhygienic jobs. The faeces is collected usually with bare hands and carried on the head. Due to bad conditions of roads even carts cannot be used. In 1993 the Parliament passed the "Employment of Manual Scavengers and Construction of Dry Latrines (Prohibition) Act" to abolish service latrines and outlaw the inhuman job of scavenging. Organisations like the *Sulabh Shauchalaya Sansthan* have been working to introduce improved latrines and provide alternative jobs for bhangis, but yet service latrines continue to exist.



iii. Pit latrine

What happens to waste in the pit latrine?

The pit latrine is simply a hole dug in the ground to collect solid and liquid wastes directly. Liquids seep into the ground. Eventually the pit fills up and a new pit has to be dug. Gases produced by the decomposing waste rise up through the hole, giving off a stench.



iv. Latrine with septic tank

(see next page)

How is the waste carried away from the septic tank? Where do you think it goes?

If sewage gets into rivers and ponds it may harm people who drink the water.

It may also poison animals and plants.

In a latrine with a septic tank, the waste falls into a tank that might be lined with bricks. Sometimes the tank is constructed to allow liquids to seep into the soil. Otherwise (or in addition), excess liquid runs out through a pipe at the top of the tank. Usually this sewage empties into a nullah that flows into a lake, river or sea (alternatively, it could be safely drained through porous pipes into an underground drainage field, but this requires considerable space). The solid waste collects in the septic tank, where it starts to decompose, giving off gases such as methane, which is sometimes collected and used as fuel. Eventually (after a number of years) the pit fills up and has to be cleaned out. The compost can be used as a fertiliser. In a two pit system (for example the *Sulabh Shauchlaya*), the waste in one pit can be left to decompose while the other pit is being used. Note that the gases cannot go up the pipe into the toilet if the toilet has a 'water lock system' as shown here (some water always remains in the U-shaped pipe at the bottom of the toilet).

v. Flush toilets with sewers (TB p. 103)

The waste from many flush toilets goes into large sewers. Big cities have lakhs of people staying in them. What could we do with all their waste? (WorkBook page 156)

While other toilets might be cleaned with 1-2 litres of water, flush toilets need between 5 and 15 litres of water (depending on the type of toilet and tank) each time. The toilet waste, along with waste water from the bathroom, kitchen

etc., is taken out of the house through underground sewers. The picture on page 103 of the TextBook shows how sewers from different houses may join a large sewer. Sewers either run downhill or they have pumping stations along the way.

Ideally the waste should be taken to a sewage treatment plant. However, in our country, the treatment facilities are usually inadequate. Often, after removing large objects and letting some of the solid part settle, the sewage is simply let out into a river, lake or sea. This is a very harmful practice. (See below.)

7. Microbes help to decompose our waste! (1 period + field trip; TB p. 103)

Just as microbes decompose our food garbage, they decompose faeces too. They break down the faeces into parts that go back into the soil where plants can reuse them. We have to give faeces space and time to decompose. But we also have to keep the microbes in faeces from spreading around, getting into drinking water and food, and making people sick.

Wastes produced by several tens of thousands of people can be treated in a large **sewage treatment plant**. Find out if you have a sewage treatment plant nearby. Try to visit it.

Find out if faeces and sewage pose any danger to humans and other living things in your locality (WorkBook page 156).

We have an enormous problem with sewage disposal. All along our rivers are villages, towns and cities. Households, industries and agriculture all produce various kinds of sewage. What happens when if this sewage is put into the river? Water contains oxygen which is needed by plants, fish and other living things. The microbes in sewage quickly use up this oxygen.

Organic and inorganic materials in the sewage also use up oxygen when they get oxidised: sometimes this oxidation is helped by microbes. Though oxygen from the air continues to dissolve in the water, it cannot keep pace with the oxygen demand made by large quantities of sewage.

Sewage is harmful in other ways too. Our faeces contain poisons and disease-causing microbes; industrial wastes and household chemicals like detergents, acids and greases too are toxic to life; phosphates contained in detergents and fertilisers lead to multiplication of some algae which do not allow other living things to grow.

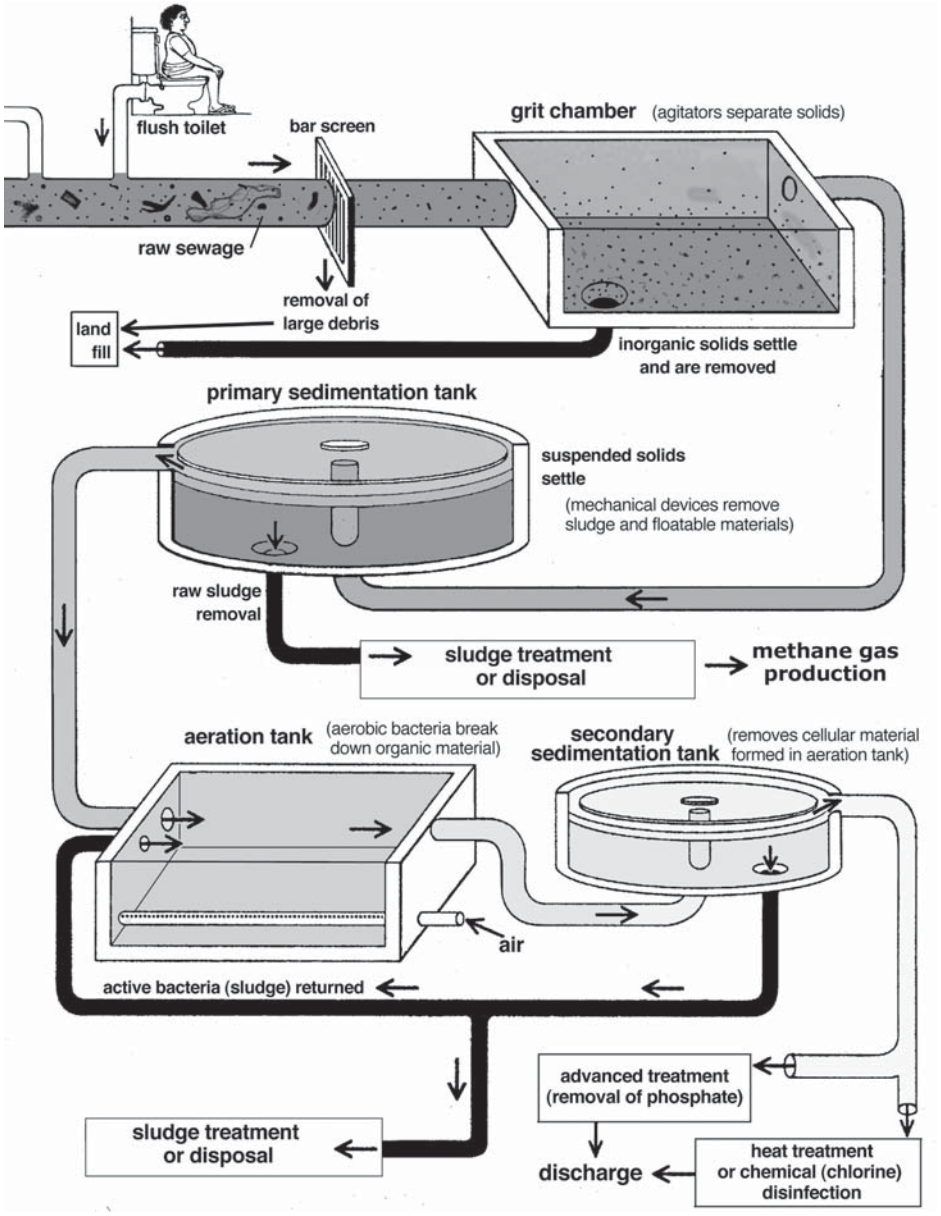
Thus sewage treatment is needed. The first step in treatment (see the diagram on the next page) is to let the sewage flow through screens to remove large objects like leaves, paper, rags, and plastic. Then it goes into a grit chamber where grit and sand sink to the bottom and are removed.

Next the sewage goes to primary sedimentation tanks where solids settle and are removed. This is called crude sludge. It may be used as fertiliser, preferably after being treated in sludge digestion tanks. There, anaerobic bacteria break down the waste, giving off methane gas (as in a gobar biogas plant), which may be used as a fuel to power the sewage treatment plant. Crude sludge can also be dried and burned as a fuel.

The liquid effluent from primary sedimentation tanks may be treated in several ways. One method is to let it out into a stabilisation pond. Even untreated sewage and sludge is sometimes treated in a stabilisation pond. This is just a large pond (lagoon) a few metres deep with a surface area of several acres. A combination of bacteria, algae and plants in the pond help decompose the sewage (the plants put oxygen into the water so that aerobic bacteria can break down the waste).

Another method of treating the liquid effluent is to use aerators or fans to mix oxygen into it, thus speeding up decomposition by aerobic bacteria.

A Sewage Treatment Plant



Aerated lagoons have been built in Versova near Mumbai. They require a lot of space and also electric power for the aerators.

In some sewage treatment plants, the sewage then passes into secondary sedimentation tanks, in which sludge is removed and recycled back into the aeration tanks. Finally advanced treatment may be used to remove phosphates and the water may be chemically treated to remove remaining microbes.

Sewage treatment plants require large amounts of water, which is not presently available in most cities. However, sewage treatment plants are being used in a few places in India (e.g. those designed by the National Environmental Engineering and Research Institute in Nagpur).

Think! Think!

What would happen if your faeces did not decompose?

Know these words

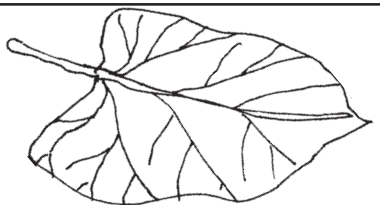
Waste water that contains faeces and urine is called **sewage**.
Ditches and pipes that carry sewage are called **sewers**.
Decompose means to break down into very small parts.

EXERCISES (8 periods + home-work; WB p. 157)

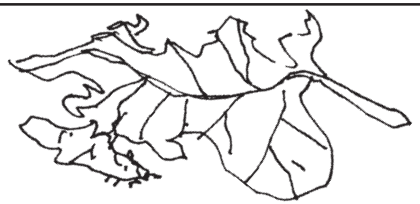
Observation-based exercises

Name and draw

1. A fresh leaf



2. A decomposing leaf



Interesting questions (WB p. 157)

1. If some liquid food like a curry is left around it starts smelling bad, and you might see bubbles in it. Remember what you know about microbes to explain this.

Students have to use the following facts: a. Microbes are present everywhere, b. They multiply quickly where they find water, food and warmth, c. Microbes make gases which could produce bubbles in a liquid, and d. Some of these gases can be smelled.

2. Name some foods that spoil (decompose) quickly and some others that last for a longer time.

This question is related to the *Show and tell* activity of Chapter 8. Only a list of foods is expected here but we might also be able to guess why some foods last a longer time: perhaps they contain less water, or a lot of salt, so microbes cannot multiply in them. (See Question 6.) Preservatives are common in manufactured food.

3. If you keep flour open it spoils. If it is covered in a box it lasts for a longer time without spoiling. Why?

Micobes floating in the air easily get into uncovered food. Small animals which visit uncovered food would bring more microbes, eggs of insects etc.

4. If you keep milk very cold it lasts for a longer time without spoiling. Why?

Most microbes need warmth to grow.

5. If you dry some foods in the sun, they keep for months or years without spoiling. Why?

Students' responses

Students knew that dried mangoes, coconut and fish keep far longer than the fresh foods. The direct rays of the sun kill microbes. Also the sun's heat evaporates water which is needed for microbes to live and grow.

Some fruits preserved by drying: mango, banana, amla, ber, tamarind, jackfruit, grapes, dates, figs, apricot, coconut, arecanut. Some vegetables preserved by drying: tomato, bhindi, karela, chillies, peas, potato, lotus stem. A variety of fish, shellfish and meats are salted and dried. Savouries like papad are made from cereals and pulses and then dried.

6. Name some ways of making food last for a longer time without spoiling. Find examples of cereals, pulses, fruits, vegetables, fish and meat that are preserved in different ways.

Most foods are seasonal, that is large quantities are available during certain times of the year when they cannot be consumed completely. Some ways of preserving food are as follows. Keep covered and airtight so that microbes do not reach it; slow down the growth of microbes by keeping the food cool - refrigerating / surrounding by water / keeping in wet sand in an earthenware pot, kill the microbes by pasteurisation and then keep the food airtight as in tinning, plastic and tertrapaks; kill the microbes with hot oil, by pickling in salt or vinegar, cooking in sugar syrup or adding citric acid - microbes cannot multiply under these conditions; dry to take away the water needed by microbes (see examples above).

Suggested activity

Cut a lemon or raw mango into pieces, mix half the pieces with salt and keep both salted and unsalted pieces in covered glass jars out in the sun for several days. Unsalted pieces spoil easily while the salted ones keep well.

7. Which do you think will decompose faster:
   a. bread or wood?
   b. dry bread or moist bread?
   c. bread in a warm place or in a cold place?
   d. a banana peel thrown away during the monsoon, or during a hot, dry season?

See the factors listed in *Interesting question* 1.

Observation and language-based exercises

Classroom discussion (WB p. 158)

1. Apart from food wastes, what other things are thrown out in your garbage? Are there things in your garbage that microbes might not decompose? What could we do with these things?
2. Why is it dangerous to keep garbage lying around? What could be done with garbage produced by several households?

Many kinds of plastics, PVC and nylon cannot be eaten by microbes though they might decompose chemically or with heat. Some petroleum products might, over many years, be decomposed by bacteria. Polythene bags could take a few hundred years to decompose naturally while thicker plastic objects could take thousands of years. In the meanwhile these items of our garbage cause enormous problems: they are eaten by cattle, fish and seals choking or killing them; the chemicals and dyes contained in plastics seep into the soil poisoning plants and animals.

It is best to minimise our use of these materials, for example we could carry cloth bags to the market, avoid throw-away cups and plates, etc.. Plastic, glass, metal and paper garbage should be separated from food garbage.

Classroom experience

Students knew the *Kabariwala* or *Raddiwala* who came around to their houses collecting old newspapers, bottles, tins etc. Separate bins had been provided in their area for glass, paper and plastic. Students knew that glass, paper and plastic could be re-used in the manufacture these same materials.

Ask and find out (WB p. 159)

1. How can earthworms help to make manure from garbage?

In Chapter 4 we discussed why burning plant waste is not desirable. The best way to dispose off plant and animal wastes is to make a **compost pit**. Food

wastes, animal dung etc. are put in a pit. Successive layers of dry leaves, soil and wood ash are put into it and the whole is kept moist. In a few months it changes to rich humus. Earthworms can help in this process. Breeding earthworms in this way is called 'vermiculture'.

2. Find the population of your village, town or city. Estimate the amount of garbage produced by so many people in one day. What is done with this garbage?

Often the garbage is dumped in a landfill. Ideally this should be done after separating toxic materials and compacting large volumes. The garbage should then be covered with a layer of soil. Landfills should be located away from water sources. Garbage might also be burnt in an incinerator, taking care to recycle the toxic fumes so that they do not pollute the air.

3. What is done with the sewage in your village, town or city?

4. Wastes produced by some places, like hospitals, small industries and factories, might be especially dangerous. Find out if there are any such places in your locality and what is done with their wastes.

The government has made rules for the disposal of specialised kinds of wastes, like biomedical wastes, industrial wastes, ash from thermal power plants, etc. Some of these wastes can be recycled, others have to be disposed of carefully to minimise their harmful effects on the environment. The garbage and sewage from these places must never be dumped with household wastes.

Show and tell

1. Look around your locality and tell the class about any places you find with garbage or sewage disposal problems.

Ask a question (WB p. 159)

1. Ask questions relating to the wastes that we produce and what we could do with them.

DID YOU KNOW?

There are many more microbes on earth than all the other living things put together!

Some kinds of microbes are used to prepare fermented foods like dahi, idli, dhokla, batura and bread. The microbes break down sugar in these foods and give off gases, mainly carbon dioxide.

Curd being a partly broken-down form of milk, is easier to digest than milk is. For fermented foods to be edible, the breaking down should be done by the right kind of microbes! If not, we say that the food has got spoilt (see Activity 3).

Schools that have used the first edition of *Small Science*

English Medium (Small Science):
A.K.Joshi English Medium School, Thane; Delhi Public School, Rajkot; GEAR Innovative International School, Bangalore; Kongu Kalvi Matric Higher Secondary School, Tamil Nadu; Mayoor School, Rajasthan; Rajmata Krishna Kumari Girls Public School, Rajasthan; Rishi Valley School, Andhra Pradesh; Saikrupa, Noida; Sandipani School, Nagpur; Sanskriti..The School, Ajmer; Shikshantar School, Harayna; Shishuvan School, Matunga; The Sahyadri School, Pune; Vivek High School, Chandigarh; Anand Niketan, Ahmedabad; The Sun School, Andhra Pradesh; Christel House India, Bangalore; Heritage School, New Delhi; Satya Public School, Kakinada.
Marathi Medium (Halke Phulke Vidnyan):
Avishkar School, Nashik; Anand Niketan, Nashik; Gram Mangal, Thane; Aksharnandan School, Pune; Chetana- Vikas, Wardha;Kamala Nimbkar Bal Bhavan, Phaltan.
Hindi Medium (Halka Phulka Vigyan):
Distributed by Eklavya in Madhya Pradesh.

FURTHER READING

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Unit 3: Water

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